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CONSTRUCTION AND ARRANGEMENT OF CITY MILK PLANTS[1]

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INTRODUCTION

The milk supply of our large cities and towns is shipped in from the country for considerable distances, either directly to the city where it is to be consumed or through country receiving stations. The milk, on arriving at the city plant, is inspected for flavor and odor, tested for butterfat content and bacterial count, pasteurized, and put into bottles ready for delivery to the consumer.

The modern city milk plant has been developed in order that the milk may be handled in a sanitary manner, properly pasteurized to kill the bacteria present in the raw milk, put into the various-sized containers properly cleaned and treated to kill bacteria, and so delivered to the consumer as a safe, healthful, high-quality product.

The purpose of this circular is to furnish specific information on the construction and arrangement of modern milk plants, as an aid to those who wish to build new plants or remodel old ones.

The milk plant should be a modern sanitary building (fig. 1) of durable construction, equipped with sanitary and up-to-date apparatus. It should be so arranged that the milk can be received and handled efficiently and economically. Proper facilities must be provided for receiving, weighing, and sampling the milk, and washing the cans.

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[1] This circular is a revision of and supersedes U. S. Department of Agriculture Bulletin 849, City Milk Plants—Construction and Arrangement.

From the receiving tank the milk goes to the clarifying or filtering apparatus, and thence to the pasteurizing machinery and the bottle fillers and cappers. After the milk has been put into bottles and sealed, it must be kept in a cold place until it is sent out on the delivery wagons or trucks. Facilities must also be provided for checking in the empty bottles from the delivery routes, storing them, and properly cleaning them before they are filled with milk or cream.

PRIMARY CONSIDERATIONS IN ESTABLISHING A PLANT

While new milk plants are almost constantly being established, it should be remembered that such ventures are not always successful. In order for a milk plant to be successful certain fundamental conditions are necessary. Many milk plants have failed, not because of faulty management or changed conditions, but because the milk plant should not have been established in the first place. Before the prospective operator engages in the milk business the following questions should be answered to his satisfaction.

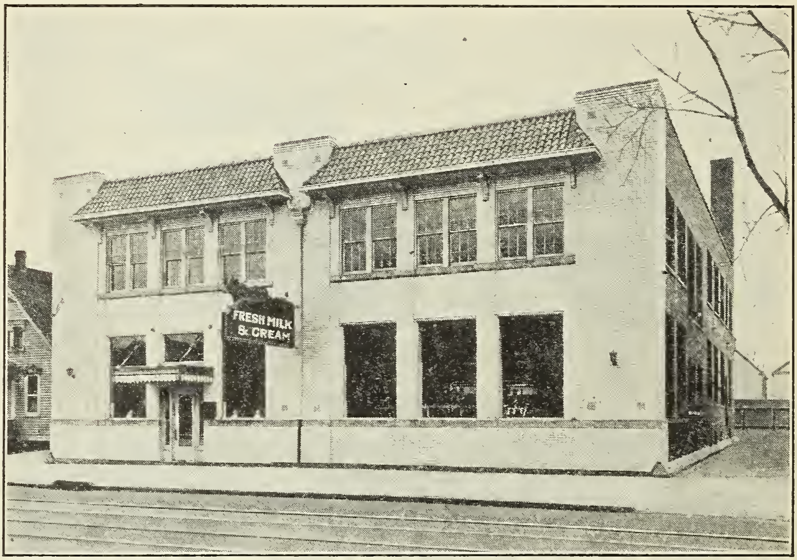

FIGURE 1.—Exterior of a modern city milk plant

What will be the probable spread or margin between the purchase prices for raw milk and the prices received for bottled milk, cream, and other products to be marketed, and will it be possible to operate the business on that margin?

Is the man who will be in charge of the plant familiar with the milk business? Unless a capable manager can be obtained, the chances of success will be greatly lessened, as the success of a milk business depends primarily upon the manager.

Is there capital enough available to equip a modern sanitary plant and operate it until it reaches a paying basis?

Is there a sufficient supply of milk of proper quality available, or can enough be made available to operate the plant successfully?

Is there a steady demand for milk in the locality under consideration, and is this demand being met by dealers already in the business?

What type of competition will be encountered?

What is the attitude of the local health department? A capable health department can be of great help to a plant that is putting out a high-grade product.

What is the local labor situation? Can reliable help be procured?

Are the householders in the community able and willing to pay a fair price for a high-grade product? Do they pay their bills promptly?

Can the community be induced to use more milk? Will it be possible to work up a trade in other products, such as cream, buttermilk, butter, and cottage cheese?

There are also minor considerations; but if the foregoing conditions are favorable, the advisibility of establishing a new plant in the vicinity will be greatly enhanced.

HINTS TO PROSPECTIVE BUILDERS

The construction of a city milk plant requires careful study and planning. The building represents a large investment, and it is important that the plans be carefully laid. The efficiency of the plant will depend to a large degree upon the type of equipment to be used and the arrangement of the various rooms and machinery. It is possible for a well-arranged plant to effect great economies in labor, while a poorly planned plant may become a continual source of extra expense, because of the excessive labor required.

Anyone who contemplates building a new plant will do well to visit various up-to-date plants in different cities in order to get the latest ideas on construction, layout of rooms, and equipment. If it is impossible to visit other plants, plans and specifications for modern plants sometimes can be obtained and ideas gained from them. By combining the ideas of other operators with his own, the prospective builder can usually incorporate the best features in the new plant.

After the prospective builder has selected a site for the plant and determined about what is needed, he should explain his general plan to a competent architect and have the architect draw up tentative sketches and plans, which may then be studied in detail. Of course, it is desirable to have previously decided upon the type of machinery to be used, since the general arrangement of the plant will depend a great deal on the type of equipment used.

It may be well to have several plans drawn, each adapted to the use of a particular type of machinery. In case it is found necessary to make changes, they should be made in the plans before construction has begun, as it is expensive to make alterations in a plant after its erection. It would be well, also, to have the preliminary plans reviewed by others experienced in the business and by health officials before the final plans are drawn.

For plants of small capacity less detail is necessary, and frequently the plans can be completed without the aid of an architect.

LOCATION OF PLANT

The principal points to bear in mind in locating a plant are: (1) Ease of access from as many sides as possible, (2) value of property, (3) cost of getting milk to the plant, (4) proximity to distribution center, (5) advertising possibilities, (6) opportunity for retail-counter cash trade, (7) nearness to city water supply and electric power, (8) avoidance of heavy traffic surroundings, (9) good drainage, and (10) pure air and clean surroundings.

Ease of access to the plant is very important. If a plant can not be approached from at least two sides, it is difficult to arrange it economically and conveniently. A plant on a corner lot with an alley in the rear is desirable, but is seldom obtainable in the down-town section of a city without great expense.

The high value of down-town property in many cities prohibits its use as a site for a milk plant. In small cities, however, the extra advertising value and the cash trade gained by having the plant in the down-town section might warrant such a location.

The cost of getting the milk to the plant is an important consideration. If the bulk of the milk is to be received by railroad, it may be advantageous to build the plant near the railroad; but if the milk is to be received largely by trucks, such a location is not advantageous. If a large quantity of milk is to be handled, it is usually desirable to establish the plant at the most convenient place for receiving the milk, and to establish distributing branches in the residential sections of the city. By having one large plant, economies can be effected in the pasteurizing and bottling of the milk, and the bottled milk can be transported in large trucks to the distributing branches, from which it is sent out on the delivery wagons. The use of large trucks and trailers for transporting milk to the distributing centers is much less expensive than is the use of small delivery wagons. Furthermore, accounting departments are usually established at the branch plants to facilitate the keeping of the customers' records and the checking of the route men.

As a rule, where branch distributing plants have been established in conjunction with the main pasteurizing plant, the main plant will be nearer the wholesale trade, and most of the wholesale milk-delivery routes will be supplied by it, whereas the majority of the retail milk-delivery routes will be supplied from the distributing branches.

One pasteurizing plant which had two branch distributing plants, had the milk-delivery routes shown in Table 1.

TABLE 1.—*Wholesale and retail delivery routes at one pasteurizing plant*

Plant or branch	Wholesale routes	Retail routes
Main plant	12	39
Branch No. 1	4	26
Branch No. 2	3	28

By locating the plant near the center of distribution, or by establishing distributing branches, delivery costs may be considerably lessened, and in some cases two delivery trips may be made during the day.

Some dealers plan to establish their plant in or near a section of the city where considerable development is anticipated. In this way they endeavor to obtain the trade of people moving into that section, and the plant itself acts as an advertisement.

In few cities is any difficulty encountered in getting an adequate supply of water and electricity, but, nevertheless, it is well to consider these items.

Congestion of traffic is of small consequence in a small town, but in a large city it may assume considerable importance.

Good drainage and clean surroundings are essential for an up-to-date plant. Some plants have been located opposite parks so that the air may be comparatively free from dust. At plants in a thickly settled part of the city it is often necessary to filter the air that comes into the building.

In recent years the tendency in building milk plants has been to establish the plant in a section of the city where the cost of property is not excessive and where a lot of ample size can be procured, so as to make provision for subsequent expansion. Furthermore, buildings of one or two stories, which are more economical in labor requirements than multiple-story buildings, require a larger area of land than a multiple-story plant of the same capacity. With the increasing use of tank-car transportation, large plants are often established near the railroad, so that the milk may be received directly from the tank cars.

TYPES OF PLANTS

CLASSIFICATION BASED ON THE METHOD OF HANDLING THE MILK

Milk plants may be grouped according to the method by which the milk is handled in the plant in seven classes. The number of plants falling in each class, as shown by a survey of 336 plants, is given in Table 2. The plants are classified on the basis of the method of handling the milk as follows:

TABLE 2.—*City milk plants classified as to course of the milk through the plant*

Capacity of plant in gallons	Number of plants in the class stated							Total
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
100 or less	0	0	0	0	0	11	0	11
101 to 250	1	0	0	0	0	37	0	38
251 to 500	0	0	6	1	0	24	0	31
501 to 1,000	0	0	6	2	0	23	0	31
1,001 to 2,000	0	1	5	3	0	28	0	37
2,001 to 3,000	0	0	1	7	0	7	0	15
3,001 to 5,000	1	3	1	17	0	17	0	39
5,001 to 10,000	1	2	2	47	7	6	0	65
10,001 to 15,000	0	2	1	18	3	1	0	25
15,001 to 20,000	0	1	0	11	3	0	0	15
20,001 to 30,000	0	1	0	9	6	1	0	17
Over 30,000	0	1	1	3	3	2	2	12
Total	3	11	23	118	22	157	2	336

Class 1. Milk handled by gravity (in buildings of more than one story). In this class of plants the milk in cans is elevated above the first floor and dumped into the weigh can on an upper floor. It then

flows by gravity through pasteurizing and other machinery without the use of a milk pump. (Fig. 2.)

Class 2. Milk handled by gravity and pump (in buildings of more than one story). The milk is elevated in cans above the first floor and dumped into the weigh can on an upper floor. From there it flows by gravity through part of the machinery, but pumps are used before it reaches the bottle filler.

Plants of the class 1 and 2 type are rather uncommon, as it has been found to be more economical and satisfactory to pump the milk than to elevate it in cans by means of elevators or escalators. (See Table 5.) Provided the pump is of proper design and is kept clean, there is no great objection to pumping the cold raw milk from a receiving tank on the first floor to the raw-milk storage tanks or to the pasteurizing department.[2] The economy of dumping the milk and washing the cans on the first floor is of considerable importance, and much labor, time, and power may be saved by handling cans in that way rather than elevating the full cans and, after they have been dumped, sending them back on an elevator or escalator. In plants where there is not room enough on the ground floor for weighing, sampling, and grading, it may be convenient to send the milk upstairs in cans. This system as a rule is more expensive, as is shown in Table 5.

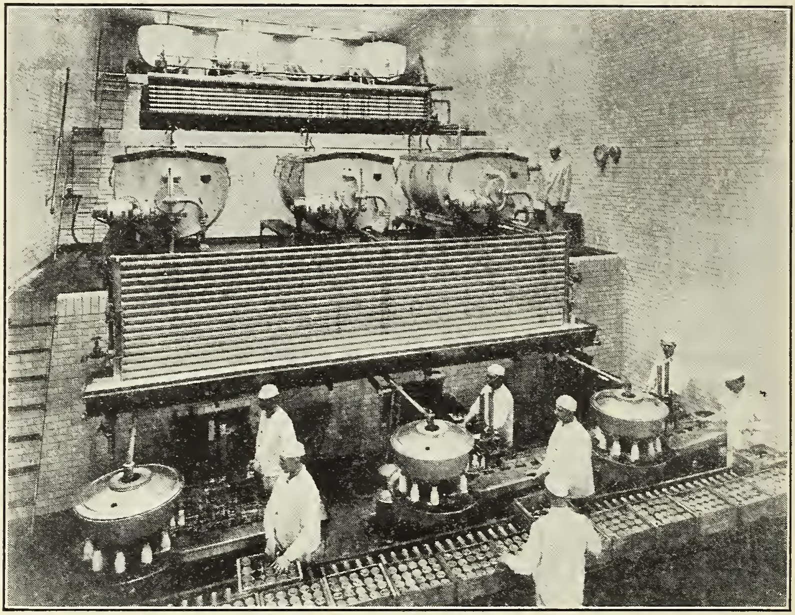

FIGURE 2.—View of equipment in a milk plant of the gravity type, represented by class 1

Class 3. Milk pumped to higher level, then handled by gravity. The milk is dumped into a tank on the first floor and is pumped to a floor above, whence it flows through the various pieces of apparatus by gravity, without the further use of a milk pump. (Fig. 3.)

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[2] WHITTAKER, H. A., ARCHIBALD, R. W., SHERE, L., and CLEMENT, C. E. EFFECT OF VARIOUS FACTORS ON THE CREAMING ABILITY OF MARKET MILK. U. S. Dept. Agr. Bul. 1344, 24 p., illus. 1925.

Some of the most modern large plants, which vary in height from two stories upward, belong in class 3. Plants of this type have the desirable feature of dumping and weighing the milk on the first floor, and are more economical in costs of receiving milk than the plants of the class 1 and class 2 types.

Class 4. Milk pumped to higher level, then handled by gravity and pump. The milk is pumped from a receiving tank on the first floor to a floor above. From that point is is handled by pumps, or partly by pumps and partly by gravity. (Fig. 4.)

Many of the larger plants are of the type represented by class 4. Plants of this type have the same advantages in receiving milk as the plants of class 3, and, in addition, can often be operated with a smaller number of men, because the various pieces of apparatus are comparatively close together, and, in some cases, are on fewer floors. In most of the plants of class 4 the milk after pasteurization is handled with pumps, and the number of milk pumps and the length of piping required are usually greater than in plants of the other classes.

Class 5. Milk pumped to higher level, then handled by gravity and pump. This method of handling the milk is similar to that in plants of class 4, except that the bottles are filled on the second-floor level and the filled bottles are sent on conveyors to the milk-storage room on the first floor. Plants of this type are usually found where property is expensive and a large ground area is not available.

Class 6. Milk handled on one floor level, one or more pumps being used. A large number of plants, especially plants of the smaller capacities, are of this type. Most of the modern milk-plant equipment is adaptable to this type of plant and where ample ground area is available it has many advantages. A view of the bottling arrangement in a plant of this type, which also combines features of plants of class A type, is presented in Figure 5.

Class 7. Milk sent to storage tanks on floor below the street level, then pumped to a higher floor level, then handled by gravity, or by gravity and pumps from that point, as in classes 3, 4, and 5. The placing of the raw-milk storage tanks below the first-floor level is a comparatively new arrangement in milk plants. This arrangement appears to have some advantages, especially where milk is transported to the plant in tank trucks or tank cars, from which it may flow by gravity into the storage tanks; furthermore, space is saved in other parts of the plant.

CLASSIFICATION BASED ON THE COURSE OF BOTTLES THROUGH THE PLANT

City milk plants may also be grouped, on the basis of the course of the bottles through the plant, in the following five classes:

Class A. Plants in which all operations are on first floor. (Fig. 5.)

Class B. Those in which bottles are washed in the basement and the rest of the operations are performed on the first floor. (Fig. 6.)

Class C. Those in which bottles are washed and filled on the second floor and the milk-storage room is on the first floor.

Class D. Those in which all operations are on the first floor, except that the empty bottles are stored on an upper floor level or in the basement.

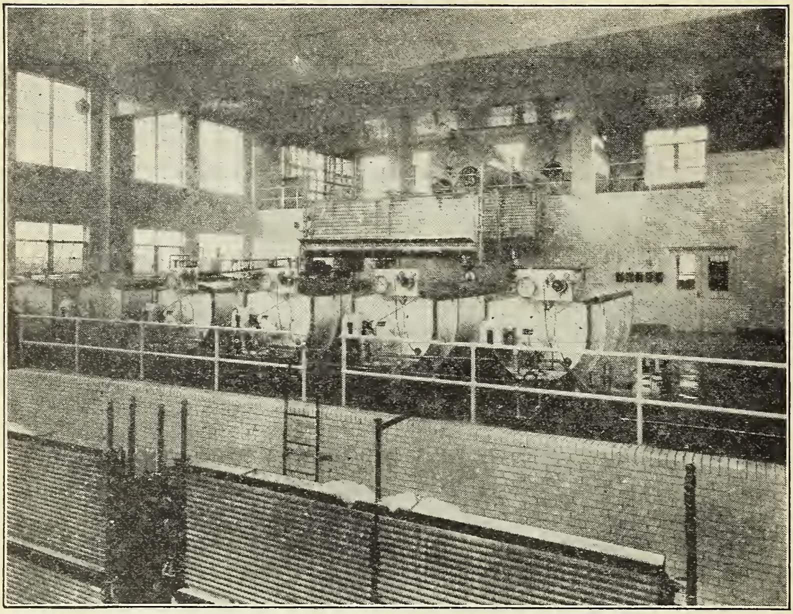

FIGURE 3.—View of equipment in a milk plant of the class 3 type

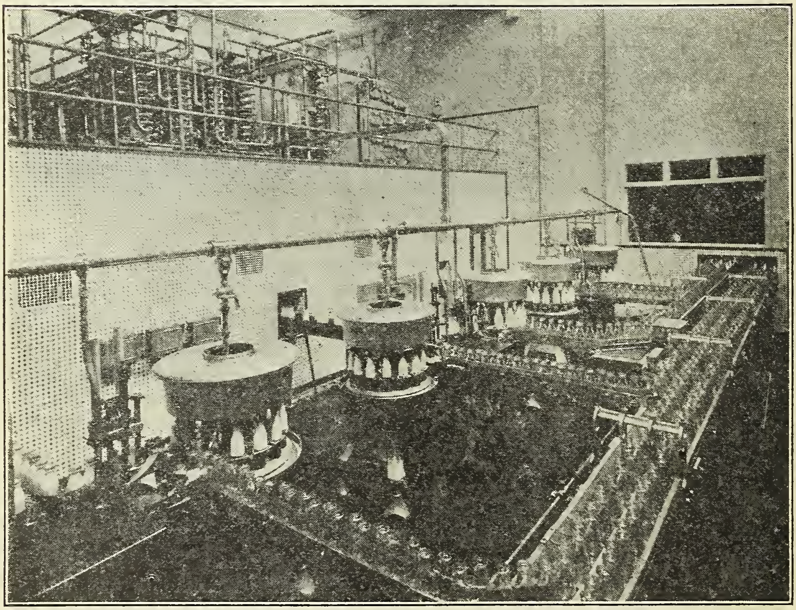

FIGURE 4.—View of equipment in a milk plant of the class 4 type

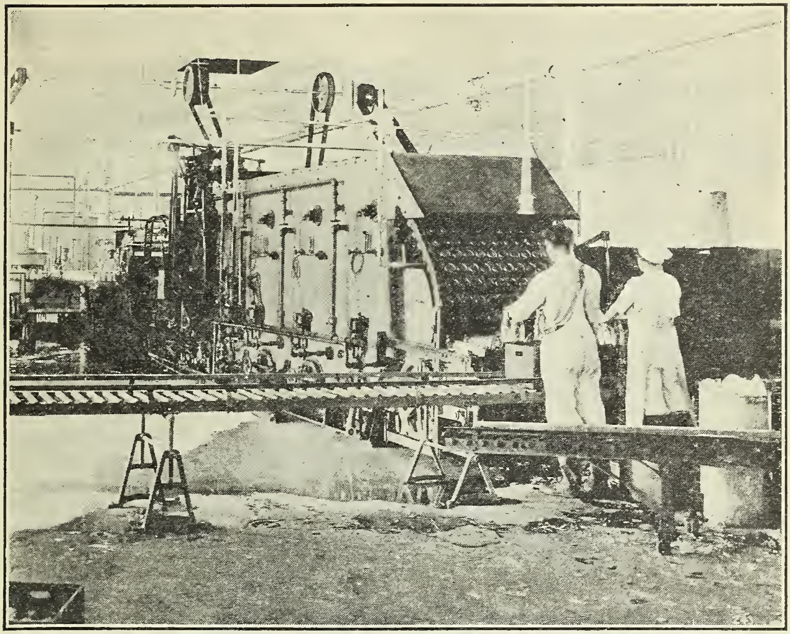

FIGURE 5.—Feeding bottles to washer in a plant combining the features of class 6 and class A types. The pasteurizers and bottle fillers are in the background

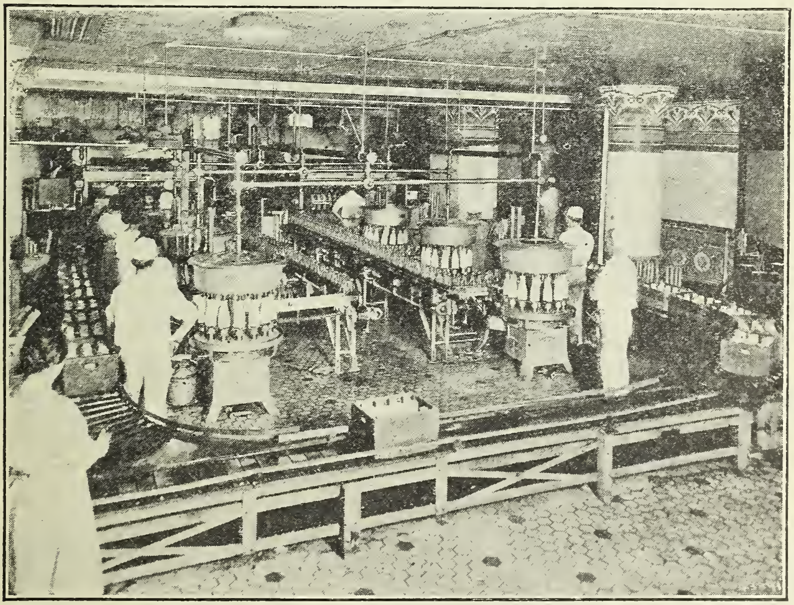

FIGURE 6.—Bottling milk in a plant of the class B type. Only the discharge end of the washer is shown. The washer itself is in the basement below

Class E. Those in which bottles are washed in the basement and the fillers are on a floor above the first-floor level and the milk-storage room is on the first floor.

In a survey of 289 city milk plants, plants of various capacities fell into these five classes as indicated in Table 3.

TABLE 3.—*City milk plants classified as to the course of bottles through the plant*

Capacity of plant in gallons	Number of plants in class—					Total
	A	B	C	D	E	
500 or less	80	0	0	0	0	80
501 to 1,000	25	0	0	0	0	25
1,001 to 2,000	26	0	0	0	0	26
2,001 to 3,000	[1] 8	1	0	0	[2] 1	10
3,001 to 5,000	27	1	1	1	0	30
5,001 to 10,000	43	5	6	1	1	56
10,001 to 15,000	14	3	2	[3] 2	0	21
15,001 to 20,000	8	1	4	2	0	15
20,001 to 30,000	[1] 7	3	5	[4] 2	0	17
Over 30,000	3	2	1	[3] 2	1	9
Total	241	16	19	10	3	289

[1] At one plant the milk-storage room was in the basement.
[2] Bottles were stored above the first floor after being washed, but were filled on the first floor.
[3] At one plant the bottles were stored in the basement.
[4] At both plants the bottles were stored in the basement.

More than 80 per cent of the plants were of the class A type, with all the operations on the first floor. As is indicated elsewhere, less labor is needed and fewer bottles are broken in plants where the bottle washing and filling departments and the milk-storage room are all on the first floor. With this type of plant, transfer of bottles between floors, which causes extra breakage, is eliminated, and fewer foremen are required than in plants where the operations are performed on different floor levels.

At plants of the class B type practically as good results can be obtained as at plants of the class A type, provided proper conveyor systems are used for conveying the dirty bottles to the washers in the basement, and the bottles, after being washed, are automatically elevated to the first floor by the washer itself. If the plant is equipped with power conveyors, properly installed, for moving the bottles to the basement, the number of bottles broken in sending them to the washers need not be large. Where gravity conveyors are used without automatic control, however, considerable breakage may result. (See under Breakage of Bottles, p. 21.)

Plants of the class C, D, and E types are not common and are usually found only in the larger cities in sections where land is expensive or where sufficient ground area was not available for a 1-story plant.

CONSTRUCTION OF PLANT

SIZE OF BUILDING AND NUMBER OF STORIES

In planning a milk plant, the building should be made large enough to accommodate a reasonable expansion of the business. If it is practicable to do so, the building should be so laid out that the capacity of the plant can be increased as desired by adding more units of machinery from time to time, without interfering with the convenient arrangement of the apparatus. Some plants are so designed that another story can be added if this should be needed to take care of increased capacity.

The type of building to be selected will depend somewhat upon local conditions and the type of machinery to be used. The more recently established plants are mostly one or two stories in height. There are but few advantages in a higher building. While a complete gravity system for handling the milk can not be installed in a 1-story or 2-story plant, the labor required to operate the plant is less than that required with a higher building.

The size and type of building has a marked effect on the amount of labor required and on the amount of milk handled per man per day. In general, more men are required in 2-story plants than in 1-story plants, but fewer than in plants of more than two stories. The subject of labor requirements as affected by the number of stories in different plants is discussed more fully in connection with Effect of Size, Arrangement, and Type of Plant on Total Labor Requirements (p. 23).

The influence of type of building on breakage of bottles is also discussed in connection with plant arrangement (p. 21).

The principal advantage of building a plant which is more than two stories high is that a smaller ground area is needed, a decided advantage when the plant is in a thickly settled part of the city. However, this consideration is becoming of little importance, as the tendency is to build in outlying sections.

Plants of the balcony or mezzanine type have the advantage that the pasteurizing equipment can be located on the mezzanine, so that the milk may flow by gravity over the cooler to the bottle fillers. This type of plant can be so arranged that the pasteurizing and bottling departments are in full view from the street.

While the size of the plant as well as the number of stories depends on the quantity of milk handled, the plant should be so planned that each man can remain on one floor and not have to go from one floor to another in doing his work, a procedure which consumes much time.

The ceiling of the plant should be at least 12 feet high. When the pasteurizing equipment is on a balcony, midway between the ground floor and the second floor, the handling room and the bottling room should be two full stories.

A survey of 307 city milk plants (Table 4) showed that 98 were of only one story, that 132 were of two stories, and that only 77 contained more than two stories.

TABLE 4.—*Number of stories in 307 milk plants*

Capacity of plant in gallons	Plants having—				Total plants in group
	One story	Two stories	Three stories	Over three stories	
500 or less	23	8	1	0	32
501 to 1,000	17	15	1	1	34
1,001 to 2,000	15	24	4	1	44
2,001 to 3,000	7	22	6	1	36
3,001 to 5,000	14	22	7	3	46
5,001 to 10,000	16	27	15	2	60
10,001 to 20,000	4	10	15	2	31
Over 20,000	2	4	13	5	24
Total	98	132	62	15	307

CONSTRUCTION MATERIALS AND FINISHES

The materials which should be used for the construction of a new milk plant will largely depend on the local conditions. The most satisfactory materials for building milk plants are reinforced concrete, hollow tile with cement finish, or selected brick. When concrete is used, the inside walls should be finished with a smooth surface, preferably of waterproofed cement, and protected with the paint that will best stand hot water and steam.

A large proportion of milk plants are of brick, and many are built of wood. Concrete is becoming very popular in many localities and is very satisfactory for milk plants. It is practically fireproof, very sanitary, weather resistant, and durable. Hollow tile with stucco finish is also much used for milk plants. With that type of construction the inside walls must be finished with cement or similar material. Many plants are now built of selected brick with cement finish on the inside—a very satisfactory type of construction.

INSIDE WALLS AND CEILINGS

For the inside walls a material should be selected that will provide a smooth, easily cleaned, durable, waterproof surface. The walls should be coated with a water and steam resistant paint. If wooden walls or partitions are used, the concrete base or a concrete apron should extend about 2 feet up the wall from the floor, as that part of the wall is exposed to water a large part of the time.

For the inside walls of rooms where milk is handled, enamel brick, tile, enamel cement, or cement plaster is satisfactory. Either tile or enamel brick is preferable, but is rather expensive. The different materials used in 20 plants which had special material for these rooms were as follows: Enamel brick, 12 plants; tile, 4 plants; cement plaster, 1 plant; enamel cement, 3 plants.

All the foregoing materials have a smooth surface and are easily kept clean. They give the room a sanitary appearance and are good reflectors of light. Enamel brick is less expensive than tile and is much used for the walls of milk-handling rooms.

Ceilings are usually constructed of materials similar to those used on the inside walls. As in the case of the inside walls, the ceiling should be smooth, durable, easily cleaned, and as nearly waterproof and steamproof as possible.

FLOORS

Floors in milk plants are usually exposed to heavy wear and much moisture. Some plants have wooden floors. The disadvantages of wooden floors where milk is handled are that they have only a short life, because of the wear and the rot, and that the milk soaks into the wood and between the cracks, causing bad odors and insanitary conditions. A tight wooden floor may be satisfactory for a short time if it is washed often. Some form of concrete floor with a waterproof finish is the one most commonly used. Sometimes, where an old building with wooden floors is used for a milk plant, a concrete floor may be laid over the wood, if the underpinning is strong enough. If properly made and finished, a concrete floor is smooth and waterproof and can be easily cleaned with hot water from a hose. Milk does not soak into concrete floors as it does into those of brick or wood, Concrete floors should be laid on a good foundation, and should be at least 3½ inches thick.

Vitreous tile also makes a very durable floor, as it is more acid resistant than concrete.

Iron plates or grids embedded in the cement protect the floor in rooms where cans and trucks are constantly being handled. An unprotected concrete floor wears out quickly if cans or trucks are continually rolled over it.

A tile floor in the bottle-filling room is desirable. Although a tile floor when properly laid is more expensive than a concrete floor, it has a good appearance, is durable, easily cleaned, and very sanitary.

Floors in the milk-handling or washing rooms should have a slope of about one-fourth inch per foot toward the floor drains. Drains should be located when the floor is laid to insure a correct slope of floor and should be trapped and connected with the sewer. They should be from 6 to 8 inches wide and have perforated, removable covers. In some plants the floors are sloped toward the outside walls, with the drains along the sides of the room. Great care should be taken in laying the floor to avoid making hollows in which water may collect. Before installing the plumbing, it is advisable to be sure that the specifications conform to local plumbing regulations.

THE MILK-STORAGE ROOM

The milk-storage or refrigerator room must be well insulated to keep the milk always at low temperature. The most common insulating materials are cork board, mineral wool, vegetable fiber, sawdust, and shavings, which are used as fillers in walls of wood, cement, or masonry. Cement plaster should be applied over the insulating material for the inside walls and ceilings in order to protect that material from moisture. One of the most satisfactory types of construction is about 4 inches of cork-board insulation with cement plaster applied on the inside.[3] The floor of the refrigerator room should be of concrete laid solidly on the insulating material. Good drainage to a drainpipe, carefully trapped to prevent warm air from entering the room, is very important.

In order to save refrigeration as much as possible, only a minimum of wall surface should be exposed to the outside air or sun. The doors of the room should fit tightly, swing outward, and be adapted to quick handling. A vestibule, while taking up some extra space, will prevent considerable loss of refrigeration.

ARRANGEMENT OF PLANT

In the arrangement of the rooms and equipment, economy of operation as well as sanitation must be considered. The rooms and equipment should be so laid out that the men can perform their work with the fewest possible steps and that the space will be used most economically. The equipment should be so arranged as to permit easy access for cleaning. It requires more time and labor to clean places which are difficult of access, and they are likely to be neglected.

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[3] For detailed information as to construction of storage rooms, see the following publication: BOWEN J. T. REFRIGERATION IN THE HANDLING, PROCESSING, AND STORING OF MILK AND MILK PRODUCTS. U. S Dept. Agr. Misc. Pub. 138, 58 p., illus., 1932.

Another point to be considered in arranging the rooms and machinery is the reduction to a minimum of pumps, pipes, and fittings. Long lengths of piping and numerous fittings are expensive, cause extra labor, and in the case of milk piping may be insanitary if not cleaned regularly. They also tend to increase the loss of milk, both from milk sticking to the sides of the pipes and from leaks at joints. Wherever milk piping is used, it should be of simple and sanitary construction, with frequent unions so it may be readily disconnected for cleaning. It is important to have all turns in the pipes easily accessible and easily cleaned. Elbows and tees are to be avoided as much as possible, but when they are used, openings at the end will facilitate cleaning. Right-angle bends may be used if there is sufficient space. There is less friction to the flow of milk in this type of joint than in an elbow. Also, bends are more easily cleaned than elbows, as there are no recesses in which dirt can collect.

At 73 plants the number of milk pumps used varied from 0 to 4, and the total length of milk piping used ranged from practically 0 to 300 feet. There was a wide range in these two items in plants in the same class, as well as in plants of the same size. For example, at 26 plants of the class 4 type the length of milk piping ranged from 20 to 210 feet, and the number of milk pumps ranged from 2 to 4; and at 20 plants handling from 2,001 to 5,000 gallons daily, the length of the milk piping ranged from 30 to 300 feet, and the number of milk pumps from 0 to 4.

The course of the milk through the plant should be as direct as possible from the receiving tank, through the processing and bottling equipment to the milk-storage room, and out to the delivery wagons. Mechanical conveyors should be used wherever labor and time can be saved; otherwise the extra expense incident to their use is not warranted.

RECEIVING THE MILK

The receiving room should be so arranged that the milk can be received and weighed with as small a labor cost as possible. In a study made at 63 plants at which the milk was received in cans, it was found that the best results as to time and labor required were obtained at those plants where the cans of milk were transferred from the receiving-room door to the dump or weigh can by means of conveyors. (Fig. 7.) At the latter plants the cans, after being dumped, were transferred directly to the can washer, from which they passed on to the trucks, either directly or by means of conveyors. At 23 plants which used a system similar to the one just described, an average of 2,334 gallons were received per hour and 459 gallons per man-hour.

At 23 of the 63 plants, the cans were either rolled to the weigh can (fig. 8) or transferred from the receiving door to it by means of platform trucks. The quantity of milk handled per hour and per man-hour was less than half what it was at the plants using some system of conveyors. At small plants a conveying system may not be necessary, as often the weigh can may be placed close to the receiving-room door. At 7 plants with this arrangement the milk was received at the rate of 1,506 gallons per hour and 613 gallons per man-hour. While the labor cost per gallon received was slightly less at these plants than at the plants using the conveyor systems, such an arrangement is only adapted to small plants. Large plants should be so arranged that the cans of milk will be automatically conveyed to the dump or weigh

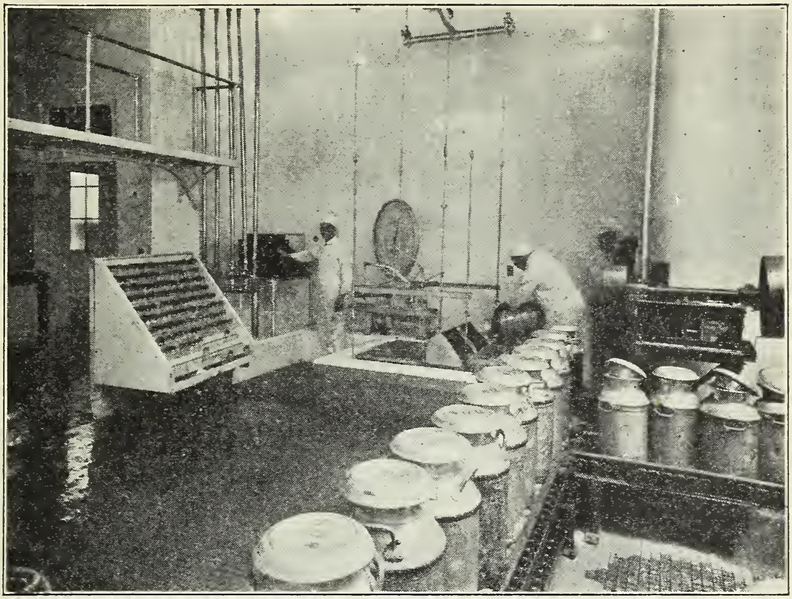

FIGURE 7.—Receiving milk at a plant using a conveyor system

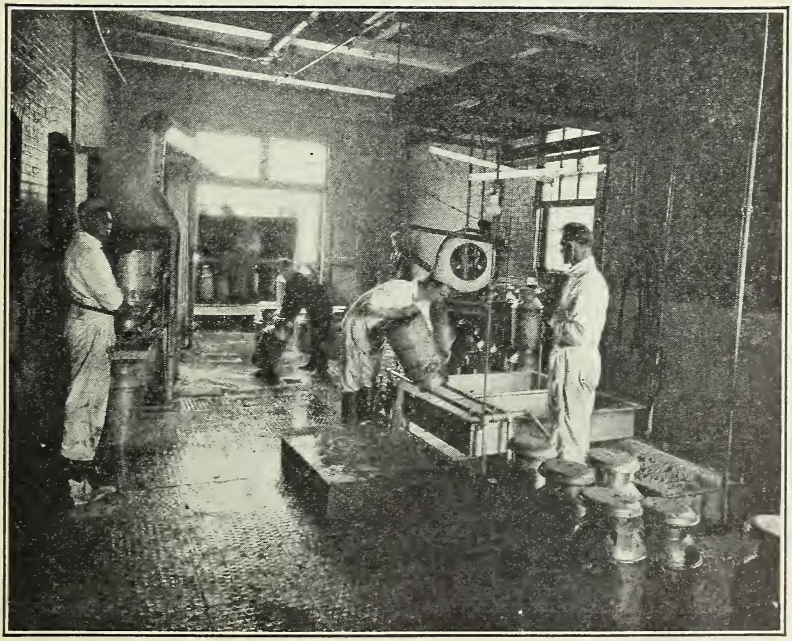

FIGURE 8.—Lack of a conveying system at this plant caused extra labor in receiving the milk

can and pass directly through the can washer and out to the trucks either directly or by conveyor.[4]

MILK PUMPS AS COMPARED WITH ELEVATORS AND CONVEYORS

Very few plants elevate the milk to the upper-floor levels in the cans; most plants use pumps. (Pp. 5 to 8.) Studies were made at 28 typical plants in order to determine the relative economy of three different systems of handling cans of milk, as follows: (A) The milk is dumped from the cans into tanks on the first floor and then pumped to the receiving tank above, (B) the cans of milk are elevated from the first floor to the floor above by means of power conveyors (fig. 9), and (C) the cans of milk are elevated from the first floor to the floor above by means of freight elevators. A comparison of the economy of the three systems is shown in Table 5.

Table 5.—*Comparison of average time and labor required in receiving and dumping the milk and washing the cans at three different types of plants*

Type of plant	Plants	Cans of milk per plant	Time spent per plant	Men per plant	Labor per plant	Labor per 100 cans received	Time per 100 cans received	Cans received and dumped per hour
	Number	*Number*	*Hours*	*Number*	*Man-hours*	*Man-hours*	*Hours*	*Number*
A (pump)	18	1,034.7	4.9	4.3	26.2	2.5	0.47	212.6
B (conveyor)	6	845.0	4.9	5.7	30.8	3.6	.58	172.0
C (elevator)	4	825.0	8.1	5.8	58.4	7.1	.99	101.5

From the data in Table 5, it is apparent that the system of pumping the milk from the ground floor is much more saving of labor than the system of elevating it in cans. At these plants the pumping system was more than twice as efficient as the elevator system, and much more efficient than the conveyor system. The conveyor system, however, was more economical in the use of labor than the elevator system and required only about one-half as many man-hours to handle 100 cans of milk.

In some plants it may be necessary to have the receiving room on the top floor because of lack of space on the ground floor (fig. 10), but that arrangement should be avoided.

CHECKING IN THE ROUTES

The plant should be so arranged that the routes can be checked in rapidly and with as small a labor cost as possible. Studies made at 82 plants[5] indicated that for large plants a system of conveyors leading from the checking-in platform directly to the washers was the most economical, both as to time of unloading and amount of labor required.

It was also found that the amount of labor required for washing bottles depended to a considerable extent upon the system used in checking the routes. At 8 plants where the bottles were checked in on

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[4] See the following publication: Clement, C. E., Le Fevre, P. E., Bain, J. B., and Grant, F. M. EFFECT OF MILK-PLANT ARRANGEMENT AND METHODS OF OPERATION ON LABOR REQUIREMENTS. U. S. Dept. Agr. Tech. Bul. 153, 40 p., illus. 1929.

[5] See above publication.

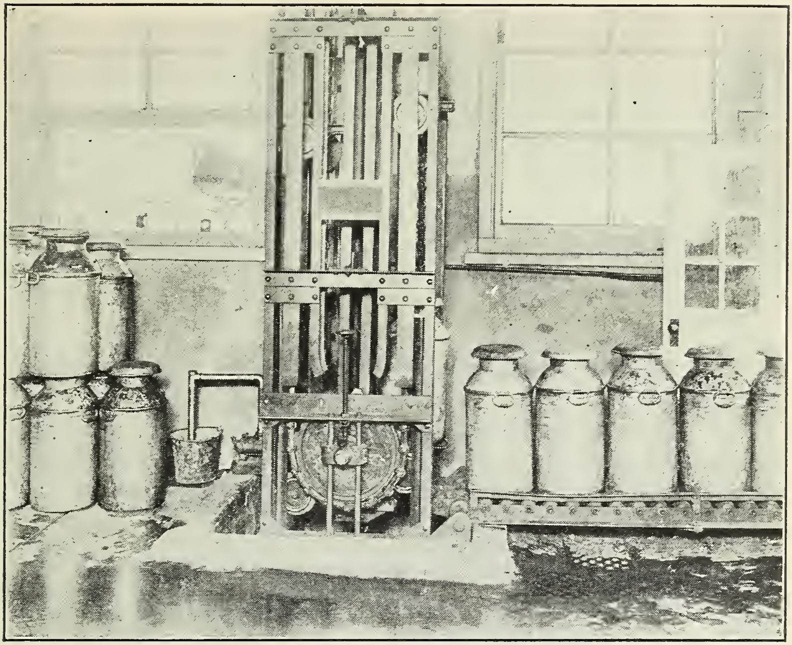

FIGURE 9.—Gravity conveyors bringing cans of milk from trucks to the power conveyor, which carries them to the top floor, where the milk is dumped

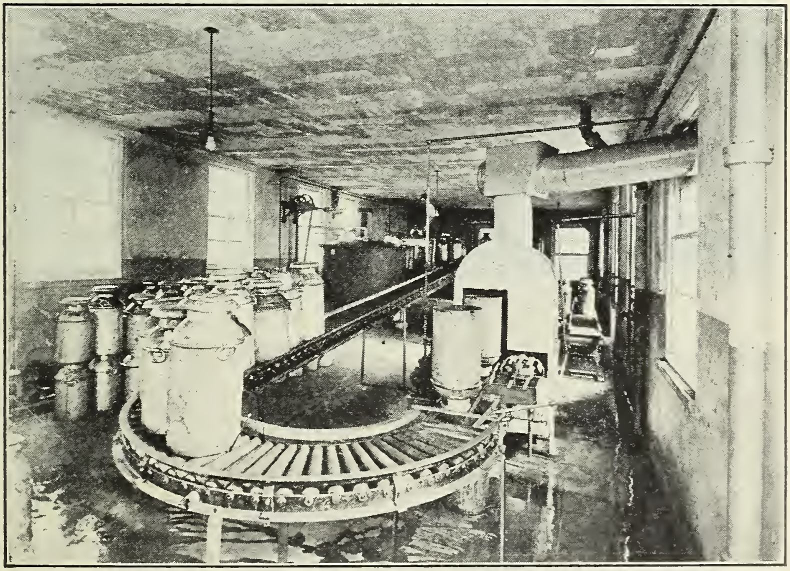

FIGURE 10.—In this plant milk is received and cans washed on the upper floor because of lack of space on the first floor. Extra labor is required with this arrangement

conveyors which led directly to the bottle washers (fig. 11), only 0.09 man-hour per 1,000 bottles was used between the point where the bottles were checked in and the point where they were fed to the washers, 8.1 routes were checked in per man-hour, and 1,204 bottles were washed per man-hour. At 25 plants where the bottles were checked in, stacked, and later transferred to the washers from the bottle-receiving platform or bottle-storage department by conveyors or trucks, 0.40 man-hour per 1,000 bottles was used in transferring the bottles to the washer, and only 4.1 routes were checked in per man-hour and 991 bottles washed per man-hour. Of course more bottles have to be sorted at some plants than at others, depending on how they come in off the routes, but these data indicate that at the average plant the best results from a labor standpoint, both in checking in bottles and washing them, are obtained where conveyors are used which lead directly from the checking-in platform to the bottle washers. At most plants using such a system it is necessary to stack some of the bottles, but for best results the conveyors should be so arranged and the two operations so synchronized that the amount of stacking will be kept as low as possible.

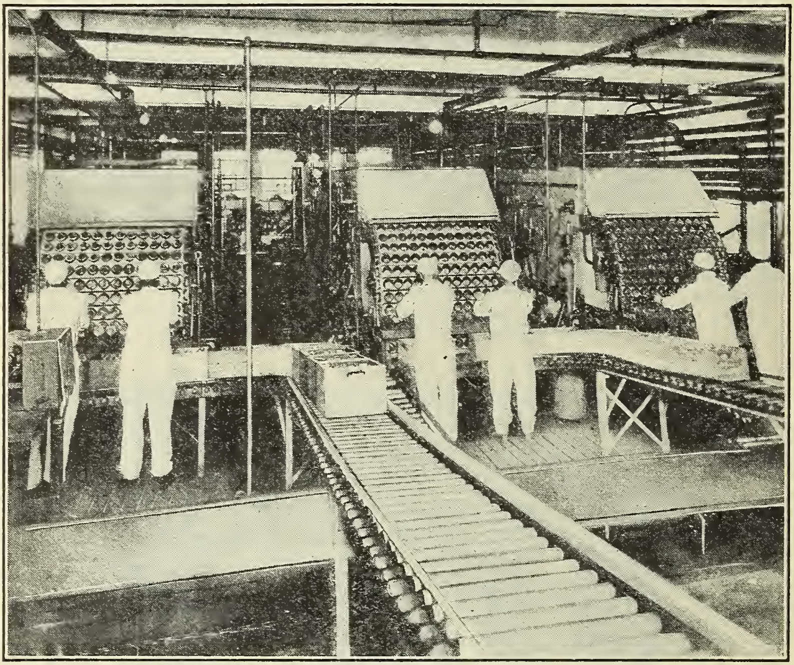

FIGURE 11.—Washing bottles at a plant where they pass on conveyors directly from the checking-in platform to the bottle washers

At small plants a transfer system between the checking-in platform and the bottle washer may not be necessary. At such plants the bottle washer may be located at a point close to the checking-in platform so that they can be fed directly into the washer. At 7 small plants with such an arrangement, 6.7 routes were checked in per man-hour and 1,639 bottles were washed per man-hour with practically no labor required between the checkers and the men who fed the bottle washers.[6]

CHECKING OUT THE ROUTES

The plant arrangement for checking out the routes will depend on the number of routes to be checked out. It is desirable that the plant be so laid out that all the routes can be checked out in at least 3 or 4 hours and in some cases 2 hours is all that can be devoted to this operation. Plants with a large number of routes must therefore be so arranged that the routes can be checked out very rapidly. In order to be able to check out a large number of routes in a short time, it is necessary to load out from several different points at the same time. At some large plants, the wagons are loaded from four or more doors direct from the milk-storage room, while at others several trailers are lined up and the wagons are loaded directly from them. Where trailers are used they are usually spotted at the distributing branches (fig. 12), having received their loads from the main bottling plant. Usually quarts of milk will be delivered to the route driver from one trailer, pints from another, cream from another, and so on; so that the wagons travel in a direct line from one trailer to the next. Likewise, when checking out from several doors direct from the milk-storage room, the driver will get one class of goods at each door, although in some cases the goods are so arranged in the milk-storage room that an entire load is put out at each door. Often, when different classes of goods are put out at the various doors, a definite number of quarts of milk are delivered to each driver from the first door, and the remainder of his quarts as well as his cream and other products are delivered at the other doors. In this way, the checker at the first door does not need to know what the load sheet calls for, as he gives each driver a basic number of quarts, as, for example, 12

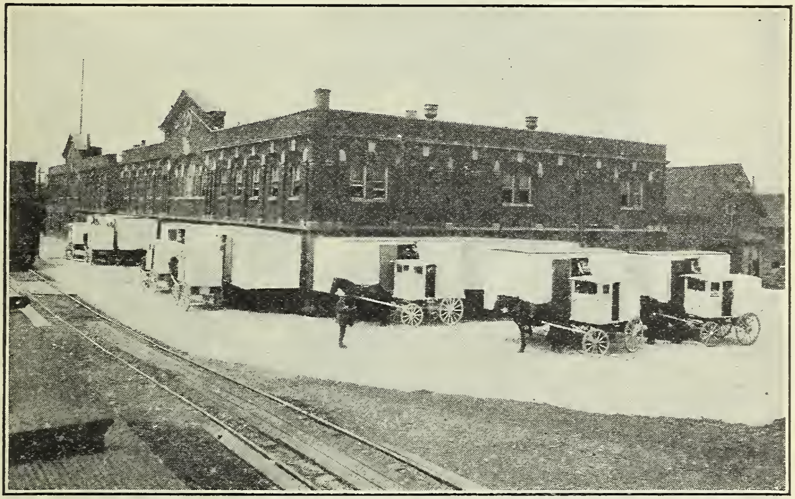

FIGURE 12.—Checking out routes from trailers spotted at the distributing plant. At seven plants using a system similar to this, on an average 53.8 routes were checked out per hour

cases or 15 cases, depending on how large loads are carried, and the driver completes his requirement for quarts of milk at one of the other doors.

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[6] See footnote 4, p. 16.

At 10 plants where the routes were checked out through four or more doors direct from the milk-storage room, on an average 42.3 routes were checked out per hour, and 4.4 per man-hour. Where seven or more loading points were used, the average number of routes checked out per hour at seven plants was 53.8, and the average number per man-hour was 3.9.

At plants which have a small number of routes to check out, it is not necessary or desirable to have so many loading points—one or two doors direct from the storage room may be used. At very small plants the routes may be checked out by trucking the milk from the milk-storage room to the loading-out platform.

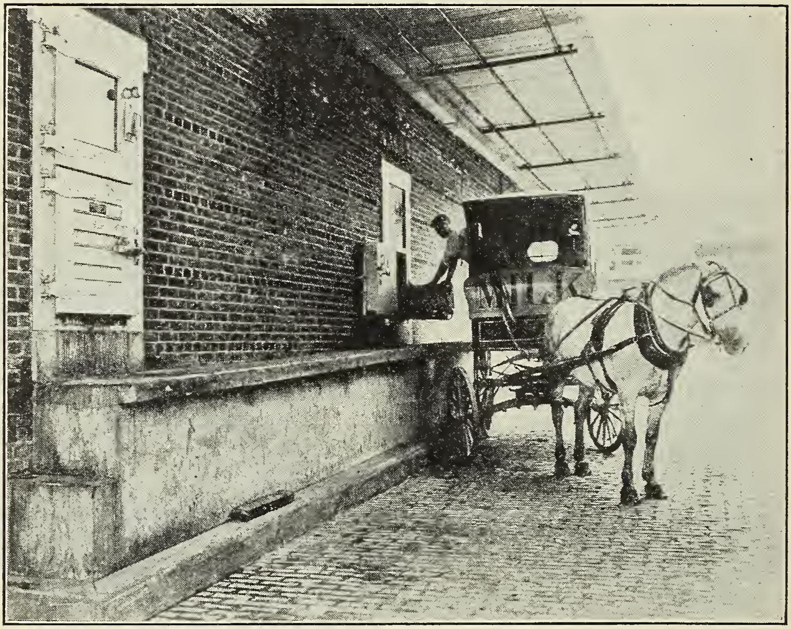

FIGURE 13.—Loading a delivery wagon at a plant checking out routes through two doors or chutes. (Only one chute was in use at the time the photograph was taken.) An average of 13.6 wagons per hour was loaded at 24 plants using this system, and the average time required to load 1 wagon varied from 2.7 to 7.9 minutes

At 24 plants which averaged 48.3 routes each and loaded from two doors direct from the milk-storage room (fig. 13), on an average 13.6 routes were checked out per hour and 4.5 routes per man-hour. At 19 plants which averaged 25.2 routes each and loaded direct from one door, 10 routes were checked out per hour and 5.1 routes per man-hour.[7] Plants with only 5 to 10 routes can check out the routes fully as economically, as to labor, by using trucks to transfer the milk to the loading-out platform.

Table 6 shows a comparison of the results obtained with different systems of checking out routes.

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[7] See footnote 4, p. 16.

TABLE 6.—*Comparison of different systems of checking out routes as to labor and time required* [1]

Group	System used	Plants	Routes			Men employed	Hours [2]
			Wholesale	Retail	Total		
		Number	*Number*	*Number*	*Number*	*Number*	*Number*
1	One chute direct to wagon	19	1.7	23.5	25.2	1.9	2.5
2	Barrel or warehouse trucks	6	13.8	40.8	54.7	6.0	5.0
3	Two chutes to wagon	24	4.1	44.2	48.3	2.9	3.6
4	Wheel platform and dolly trucks	6	6.7	45.3	52.0	3.5	3.6
5	Lift trucks	7	0.3	33.1	33.4	5.7	1.9
6	Three chutes to wagon	14	2.1	77.9	79.9	6.4	2.6
7	Four or more chutes to wagon	10	9.1	119.9	129.0	8.2	3.1
8	Loading from seven or more points	7	2.1	157.3	159.4	13.6	3.0

Group	System used	Man-hours [3]	Routes per hour [2]	Routes per man-hour [3]		Time required per route	
		Number	*Number*	*Number* [4]	*Number* [5]	*Minutes* [4]	*Minutes* [5]
1	One chute direct to wagon	4.9	10.0	5.1	5.1	6.0	6.9
2	Barrel or warehouse trucks	32.8	10.9	1.7	1.8	5.5	5.7
3	Two chutes to wagon	11.4	13.6	4.2	4.5	4.4	4.8
4	Wheel platform and dolly trucks	16.8	14.5	3.1	3.8	4.1	8.7
5	Lift trucks	16.6	18.0	2.0	3.1	3.3	3.6
6	Three chutes to wagon	19.1	30.7	4.2	4.7	2.0	2.0
7	Four or more chutes to wagon	29.0	42.3	4.4	4.9	1.4	1.5
8	Loading from seven or more points	40.5	53.8	3.9	4.0	1.1	1.1

[1] From Tech. Bul. 153, U. S. Dept. of Agr.
[2] Man-hours required for putting up orders is not considered.
[3] Man-hours required for putting up orders is included.
[4] Weighted average.
[5] Average of averages.

EFFECT OF PLANT ARRANGEMENT ON BREAKAGE OF BOTTLES

The quantity of bottles broken in milk plants per 1,000 bottles handled depends to a large degree on the arrangement of the plant. The breakage is usually greater in plants where the bottles are transferred between floors than in plants where all operations are performed on one floor. Other points in relation to breakage of bottles that should be kept in mind in laying out the plant are as follows:

Where bottles are transferred long distances, less breakage results if power-controlled conveyors are used than if gravity conveyors without controls are used. However, if gravity conveyors are equipped with stops automatically controlled by electric switches, the breakage may be kept as low as where power conveyors are used. When the gravity conveyor becomes full, the switch will automatically shut off the "booster" that brings up the cases of bottles on to the conveyor, and thus prevent any forcing or jamming of the cases on the conveyor. In plants where bottles are elevated to the second floor to be washed, the breakage is generally greater than in plants where they are washed on the first floor or in the basement, provided, in the latter case, that they are elevated, after being washed, to the first floor by the washer itself.

The best results in preventing breakage of empty bottles are obtained by having the checking-in platform and the bottle-washing room so arranged in relation to each other that the bottles can travel to the washers on conveyors with a minimum of rehandling and stacking.

When bottles are sent to a lower floor, the breakage will be less if power conveyors are used than if they are transferred by gravity conveyors.

The breakage is greater with the indirect system of washing and filling bottles than with the direct system, principally because of the extra handling involved. (By direct system is meant where the bottles go directly from the washers to the fillers without any intervening stacking.[8])

EFFECT OF TRANSFERRING BOTTLES BETWEEN FLOORS

Table 7 shows the number of bottles filled daily and the breakage at 92 plants classified according to the number of transfers of bottles from one floor to another by conveyor, elevator, chute, or other equipment. Delivery of washed bottles to a higher floor by the bottle washer itself was not considered as a transfer. For example, if the bottles were sent from the first floor to the basement to be washed and the washer itself elevated them to the first floor to be filled, with no further transfer between floors, this was regarded as one transfer.

TABLE 7.—*Effect on bottle breakage of number of times bottles are transferred from floor to floor* [1]

Transfers of bottles	Plants	Bottles filled daily	Glass broken per 1,000 bottles filled		
			Before washing	At discharge end of washers and at fillers	Total plant breakage
	Number	*Number*	*Pounds*	*Pounds*	*Pounds*
None	64	38,469	4.9	5.8	11.8
1	10	56,504	4.3	6.3	12.3
2	16	82,775	6.0	7.4	15.3
3	2	25,915	9.3	15.4	27.1

[1] From Milk Plant Letter 176, October, 1929, Bureau of Dairy Industry.

From Table 7 it is seen that the breakage increased with the number of transfers. At the plants which carried on all the operations on one floor, the total breakage per plant averaged only 11.8 pounds of glass per 1,000 bottles filled, whereas at the plants making 1, 2, and 3 transfers it was 12.3, 15.3, and 27.1 pounds, respectively. At most of the 10 plants making only one transfer, the bottles were washed in the basement, the dirty bottles being sent from the first floor to the basement by means of a conveyor or chute and the washed bottles delivered to the first floor by the washer itself. However, the breakage at these plants making one transfer was only slightly greater, on an average, than the breakage at the 64 plants where all the operations were performed on one floor. When two or three transfers were made, the breakage was considerably greater than in plants making one transfer or in plants on one floor. At the two plants making three transfers, the bottles were sent to the basement and washed; elevated to the second floor; and then at one of the plants they were filled on the second floor and transferred to the milk-storage room on the first floor, and at the other plant they were stacked and allowed to cool on the second floor and later transferred to the first floor to be filled and stored.

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[8] See the following publication: CLEMENT, C. E., BAIN, J. B., and GRANT, F. M. EFFECT OF PLANT ARRANGEMENT, EQUIPMENT, AND METHODS OF OPERATION IN RELATION TO BREAKAGE OF BOTTLES IN MILK PLANTS. U. S. Dept. Agr. Tech. Bul. 280, 29 p., illus. 1932.

While transferring bottles two or three times does not necessarily result in excessively high breakage, provided the conveyors and other equipment are of proper design and are kept in good repair, these data indicate that, at the average plant, the breakage is considerably greater where the bottles are transferred two or three times than where all the operations are performed on one floor, or where the bottles are sent to the basement to be washed and are elevated to the first floor by the washer itself with no further transfers.

EFFECT OF SIZE, ARRANGEMENT, AND TYPE OF PLANT ON TOTAL LABOR REQUIREMENTS

The number of employees required to carry on the various operations in a milk plant depends to a large degree on the layout and size of rooms, arrangement of machinery, and size and type of building. The number of men employed at 157 plants of various sizes is shown in Table 8. These figures include only men working in the plant and in the boiler and engine rooms. For plants where ice cream was handled, the time of the men in the power plant was prorated according to the quantities handled, and for plants where there was a separate butter department the men who spent all their time working in that department were not included. The figures given do not necessarily indicate the total number of men employed at one plant, but they do indicate the equivalent number of men working a full day; for example, when the average number of employees is given as 1, it may indicate that 1 man spends one-half of his time and 2 other men each spend one-fourth of their time in the plant.

TABLE 8.—*Number of men employed in 157 city milk plants of various sizes (men inside the plant only)*

Capacity of plant in gallons	Plants	Quantity of milk handled daily		Employees in plant			Employees in plant per 100 gallons handled (average)	Milk handled per man
		Total	Average	Total	Average	Variation		
	Number	*Gallons*	*Gallons*	*Number*	*Number*		*Number*	*Gallons*
Up to 100	4	250	63	4. 3	1. 1	1–1. 3	1. 7	58. 8
101 to 250	19	3, 285	173	32. 5	1. 7	1–3	1. 0	100. 0
251 to 500	31	12, 435	401	86. 5	2. 8	1. 5–6	. 7	142. 9
501 to 1, 000	34	26, 885	791	193. 0	5. 7	2–13	. 7	142. 9
1, 001 to 1, 500	16	20, 750	1, 297	114. 5	7. 2	2. 5–17	. 6	166. 6
1, 501 to 2, 000	11	19, 600	1, 782	126. 0	11. 5	6–21	. 6	166. 6
2, 001 to 3, 000	13	34, 450	2, 650	190. 0	14. 6	8–27	. 6	166. 6
3, 001 to 5, 000	16	64, 650	4, 041	328. 0	20. 5	7–36	. 5	200. 0
5, 001 to 10, 000	9	66, 700	7, 411	294. 0	32. 7	9–49	. 4	250. 0
Over 10, 000	4	69, 000	17, 250	343. 0	85. 8	49–100	. 5	200. 0
Total or average	157	318, 005	2. 026	1, 711. 8	10. 9	1–100	. 5	200. 0

These results indicate that the average number of men in each plant bears a very close relation to the quantity of milk handled. However, the number of men employed at different plants in each group varied widely, some plants employing six times as many men as other plants of about the same size. Although other factors are involved, such as the relative quantities of bottled milk handled, these figures effectually illustrated the fact that some of the plants were not being operated so efficiently as others. This is due, to a great extent, to the faulty layout and arrangement of rooms and machinery. Many plants could cut down their labor requirements by a more economical layout of machinery and equipment, while others could reduce it by installing more labor-saving machinery. Some plants have too many floors or stories to be able to utilize labor efficiently. For example, it is often necessary to have a number of men and a foreman for each floor.

In a study of the labor employed in 92 milk plants of various sizes, the results were grouped according to size of plant and the number of stories in each plant. (Table 9.) These results show that more men are required and labor is utilized less efficiently in a plant with several floors than in a plant which is handling the same quantity of milk, with only one or two floors, although the latter plant may have as much floor space as the higher building.

TABLE 9.—*Effect of type of building and size of plant on labor requirements at 92 milk plants* [1]

PLANTS HAVING ONE STORY

Group No.	Plants	Milk and cream handled per plant			Employees [2]	Milk and cream handled per employee		
		Quantity	Average	Bottled		Total	Bottled	Exclusive of checkers [3]
	Number	*Gallons*	*Gallons*	*Per cent*	*Number*	*Gallons*	*Gallons*	*Gallons*
1	5	2,000 or less	1,314	83.7	5.8	227	190	263
2	10	2,001 to 5,000	3,152	88.9	11.0	287	255	341
3	6	5,001 to 10,000	7,570	90.1	26.2	289	261	361
4	2	10,001 to 15,000	10,975	84.5	30.0	366	309	422
5	--------	15,001 to 20,000	--------	--------	--------	--------	--------	--------
6	1	Over 20,000	21,000	82.0	67.0	313	257	344

PLANTS HAVING TWO STORIES

Group No.	Plants	Quantity	Average	Bottled	Employees	Total	Bottled	Exclusive of checkers
1	8	2,000 or less	1,466	79.6	7.4	199	158	228
2	11	2,001 to 5,000	3,631	85.7	19.0	189	164	220
3	23	5,001 to 10,000	7,103	84.9	34.4	206	175	252
4	6	10,001 to 15,000	11,742	80.6	52.5	224	180	263
5	4	15,001 to 20,000	16,875	83.7	57.3	295	247	343
6	3	Over 20,000	25,261	88.1	102.6	246	217	277

PLANTS HAVING THREE OR MORE STORIES

Group No.	Plants	Quantity	Average	Bottled	Employees	Total	Bottled	Exclusive of checkers
1	--------	2,000 or less	--------	--------	--------	--------	--------	--------
2	--------	2,001 to 5,000	--------	--------	--------	--------	--------	--------
3	5	5,001 to 10,000	8,169	82.7	45.0	182	150	235
4	1	10,001 to 15,000	11,150	88.0	41.0	272	239	372
5	4	15,001 to 20,000	17,910	89.3	100.0	179	160	220
6	3	Over 20,000	31,783	89.3	115.3	276	246	327

ALL PLANTS

Group No.	Plants	Quantity	Average	Bottled	Employees	Total	Bottled	Exclusive of checkers
1	13	2,000 or less	1,407	81.0	6.8	208	169	--------
2	21	2,001 to 5,000	3,308	88.2	15.3	216	194	--------
3	34	5,001 to 10,000	7,342	85.1	34.5	213	181	--------
4	9	10,001 to 15,000	11,504	82.0	46.0	249	205	--------
5	8	15,001 to 20,000	17,393	87.0	78.6	221	192	--------
6	7	Over 20,000	27,448	88.0	103.0	267	235	--------

[1] U. S. Dept. Agr. Tech. Bul. 153.

[2] Including all men whose time was chargeable to the market-milk department. If they were used in other departments also, time was prorated. Clerks and bookkeepers were not included.

[3] At some plants the checkers are not included with the plant employees but with the delivery or sales employees.

The average number of persons employed per plant for each group is considerably lower, for plants of the same average capacity, in the 1-story plants than in the 2-story plants, and is much higher in the plants of three or more stories than in the 2-story plants. It follows that the average efficiency of the plant workmen, measured in quantity of milk and cream handled per plant employee, is higher in plants of the 1-story type; even the smaller 1-story plants comparing favorably with larger and better equipped plants of more than one story.

From this survey the best results, as to labor required, are evidently obtained in plants where the bottle washing and filling departments and the milk-storage room are all on the first floor. In this way there is a minimum of handling and of supervision required. In plants where the bottles are washed in the basement and the bottle washer delivers the bottles to the fillers on the first floor, nearly as good results are obtained.

DIVISION OF PLANT INTO ROOMS

For economy of operation and sanitation, a division of rooms is essential in the modern milk plant. Both small and large plants should have a separate receiving room, bottle-washing room, milk-handling room, and milk-storage room, as well as a separate office and salesroom. The boiler room should be entirely separate from the rest of the plant and, if possible, in a separate building. Large plants often have a somewhat more detailed division of rooms than small plants.

MILK-RECEIVING ROOM

The milk-receiving room (fig. 7) will contain the weigh can, scales, milk-sampling outfit, and either a rack or closet for the milk samples. The can-washing apparatus should be located either in the receiving room or in an adjoining room. As shown on pages 14 to 15, if the weigh can is not located at a point close to the receiving-room door, the best arrangement for saving labor is to unload the cans of milk from the milk truck upon a conveyor which carries them to the weigh can, where they are dumped by hand, and then placed by the men directly in the can washer, which delivers them automatically to the trucks either directly or by means of conveyors.

At comparatively small plants the weigh can may be so near the door of the receiving room that it is only a short distance from the truck, and the men can dump the cans of milk directly into the weigh can by taking only a few steps. If a rotary can washer is used, the cans may be placed in the washer directly after being dumped, and then placed directly on the trucks as they are discharged from the washer, very few steps being necessary. The receiving and can-washing room should be screened and separate from the rest of the plant.

MILK-PROCESSING ROOM

From the receiving room the milk goes to the pasteurizers. (Figs. 3 and 4.) At most plants storage tanks will be required to store the raw milk. These are usually located in the milk-processing room, although at some of the larger plants the storage tanks are in a separate room. From the milk-storage tanks (or directly from the receiving tanks, where storage tanks are not necessary) the milk is sent through a preheater and a filter or a clarifier, from which it goes to the pasteurizers and coolers. The milk-processing room should be separate from the rest of the plant and should be well lighted and ventilated. From the milk coolers the milk goes to the bottle fillers. While in some plants the bottle-filling equipment is in a separate room from the pasteurizing equipment, it is more often in the same room, especially at 1-floor plants. If the pasteurizing equipment is on an upper floor, the filling equipment is usually in a separate room directly under it; but if the pasteurizing equipment is on a mezzanine floor, the two are in virtually the same room.

BOTTLE-WASHING ROOM

The bottle-washing room should be entirely separate from the rooms where the milk is handled. There should be ample space for the bottle-washing machinery, bottle conveyors, and the storage of bottles.

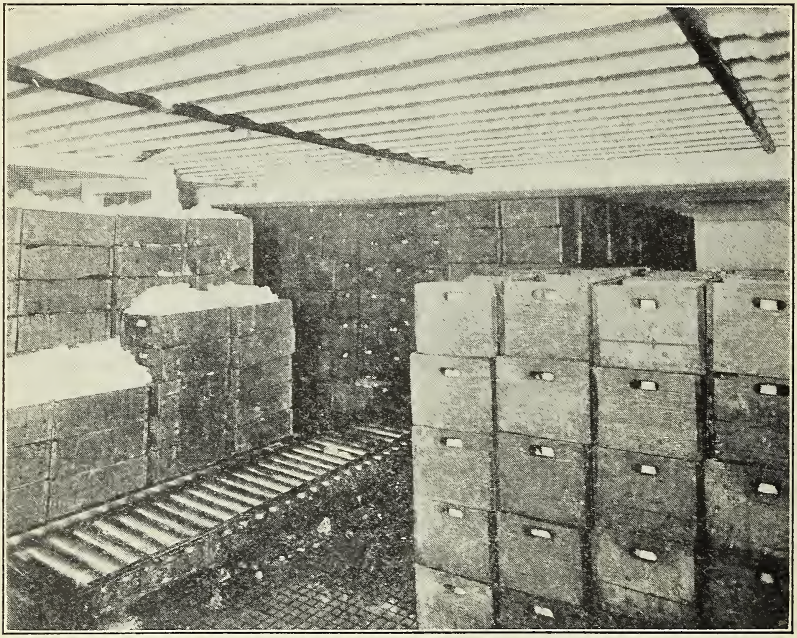

FIGURE 14.—A modern milk-storage room

MILK-STORAGE ROOM

A well-insulated milk-storage room (fig. 14) is necessary in order to store the milk at a low temperature from the time it is put into the bottles until it is sent out on the delivery wagons. The construction of the milk-storage room is discussed on page 13.

SALESROOM

The salesroom at the front of the building should be attractive in appearance and should contain a counter, a refrigerator, and perhaps a few chairs and tables for customers.

VISITORS' ROOM

Large plants generally have a special room for the entertainment of visitors. In this room special lectures on the food value of milk, etc., may be given to visitors from time to time. Women's clubs and other organizations are often given the use of such rooms for their meetings. The room should preferably lead from a balcony from which the operations in the plant can be viewed. The room should be attractive in appearance and well furnished with chairs, tables, etc., and should be a good investment to the plant for advertising purposes.

DRIVERS' ROOM

A room adjoining the office should be provided in which drivers can score their books on returning from the routes. Bath and toilet facilities also should be provided for the drivers and the employees in the plant.

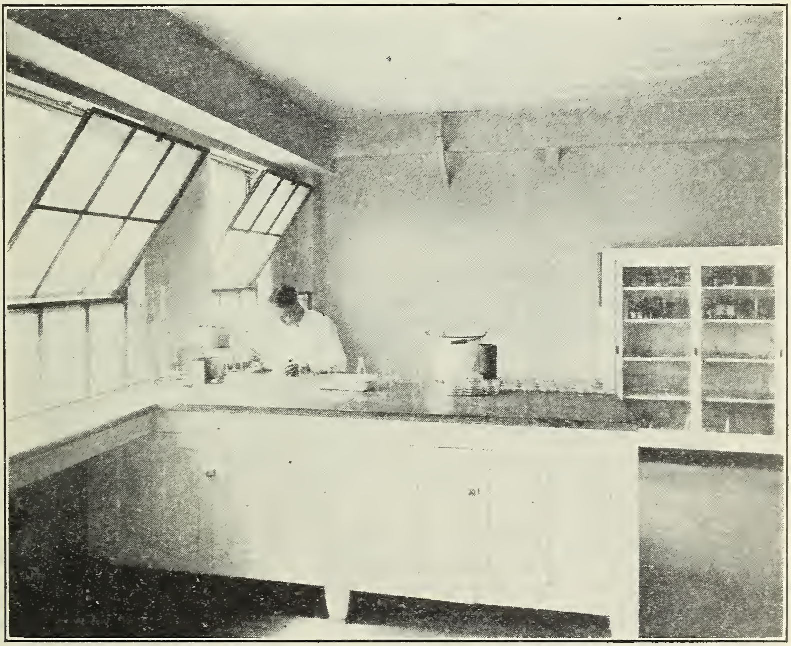

FIGURE 15.—Laboratory in a modern city milk plant

LABORATORY

A well-lighted laboratory (fig. 15) for the bacteriological and chemical examination of milk is essential for all plants. For small plants only a small laboratory is required, but large plants should have a complete laboratory with a full supply of chemical and bacteriological equipment.

BY-PRODUCTS ROOM

Space should be provided for handling by-products. Small plants require space for making only small quantities of butter, cottage cheese, and buttermilk, which sometimes may be done in the milk-handling room. In medium-sized or large plants, however, one or more separate rooms are required for the by-products department.

SIZE OF ROOMS

Each room in the plant should be large enough to avoid crowding of machinery or workmen, but at the same time there should be no unused space, for that causes extra labor in getting the milk from one piece of apparatus to another, as well as added investment.

There is a wide variation in the size of the various rooms in milk plants, as well as in floor area per 100 gallons of bottled milk handled daily. These variations are due in a large measure to the lack of standardization of milk plants, and to the fact that many plants have been constructed without consideration of important factors bearing on the size of rooms.

It is important that the receiving room be of ample size. A small receiving room soon becomes cluttered with cans and other objects, and is difficult to keep clean and attractive. At small plants, the room should be large enough to receive at least one truck load of milk in cans, either on conveyors or otherwise, with plenty of room to handle the cans without crowding. At the larger plants, it often happens that several truck loads of milk in cans will arrive within a short space of time, and it is advisable to have a receiving room large enough to store this number of cans, either on the conveyor or in stacks, until they can be dumped.

The size of the bottle-washing room will depend on how the bottles come in from the delivery wagons or trucks. If most of the bottles are sent directly from the unloading platform to the bottle washers, the room need be only large enough for the conveyor and the bottle-washing machine, with ample space for the workmen to get around the machine. As a rule, however, many of the bottles will have to be stored before being washed, and ample storage space should be provided. The conveyor should be so arranged that it will hold as many cases of empty bottles as possible, in order to save labor in stacking cases.

The processing room should be sufficiently large to contain the milk vats, clarifier or filters, and pasteurizing equipment, and still leave plenty of room for the men to work and to get around the machines for the daily cleaning. As previously stated, at some plants proper cleaning is often neglected because the men do not have space enough in which to work.

The bottle-filling room, if it is to be separated from the pasteurizing room, may be smaller than the other rooms, because at most plants the bottles usually pass continuously through the bottle-filling room and are not stored there. There should be sufficient space to enable the men to get around the machines readily and keep the room clean and tidy at all times.

The milk-storage room should be large enough to hold all the milk that the plant can handle when running at full capacity, with some extra space for emergencies, and to allow for passageways between the stacks of various kinds of products, such as pints and quarts of milk and jars of cream. Too large a room, however, is wasteful and requires additional refrigeration. The clear height between floor and ceiling need not be more than 8 or 9 feet, after allowing for a brine tank or pipes. If cases of quart bottles are piled six tiers high and pint bottles seven tiers high, about 2,000 gallons of bottled milk in cases could be stacked in an area of 15 by 16 feet, or 240 square feet, exclusive of passages. Allowing space for the men to work and for emergencies, a room about 18 by 20 feet would be needed for storing this quantity of milk. A room 12 by 15 feet in size would provide storage space for about 1,000 gallons of bottled milk. The size of room needed at any individual plant will of course depend on the proportion of milk that is held over in storage. At many of the larger plants, much of the milk is sent to delivery wagons or to branch trucks direct from the bottling department, without being stored in the milk-storage room. If large quantities of milk are stored there in cans, more space is required, as it is usually not feasible to deck the cans more than two tiers high.

The following are the approximate sizes of milk-storage rooms required for plants handling various quantities of bottled milk:

Quantity of bottled milk handled	Approximate size of milk-storage room
Gallons	*Feet*
300	8 by 8
500	10 by 10
1, 000	12 by 15
2, 000	18 by 20
4, 000	24 by 30

Table 10 shows the area of the principal rooms at several well-arranged plants of different capacities.

TABLE 10.—*Area of principal rooms in 11 representative milk plants of various capacities*

Plant No.	Milk and cream		Receiving milk and washing cans						Handling bottles					
	Handled daily	Bottled	Receiving room		Can-washing room		Total	Per 100 gallons handled daily	Dirty-bottle storage		Bottle-washing room		Total	Per 100 gallons handled daily
			Size	Per 100 gallons handled daily	Size	Per 100 gallons handled daily			Size	Per 100 gallons handled daily	Size	Per 100 gallons handled daily		
	Gallons	*Per cent*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*
1	800	93	350	43.8			350	43.8			900	112.5	900	112.5
2	1,500	95	(1)		(1)		(1)				700	46.6	700	46.6
3	3,000	90					900	30.0					1,800	60.0
4	3,800	98	252	6.6	266	7.0	518	13.6	560	14.7	1,110	29.2	1,670	43.9
5	4,000	95	460	11.5			460	11.5					2,430	60.8
6	6,000	94					1,200	20.0					2,630	43.8
7	7,500	93	228	3.0	418	5.6	646	8.6	543	7.2	993	13.2	1,536	20.5
8	9,000	72					810	9.0			2,100	23.3	2,100	23.3
9	9,800	90					1,125	11.5	4,800	49.0	2,700	27.6	7,500	76.5
10	20,000	97	1,512	7.6	3,290	16.4	4,802	24.0			7,504	37.5	7,504	37.5
11	35,000	94					4,800	13.7	3,600	10.3	3,200	9.1	6,800	19.4

Plant No.	Handling milk										Milk-storage room		Total area of important rooms	
	Raw-milk storage, pasteurizing and cooling						Bottling room		Total	Per 100 gallons handled daily	Size	Per 100 gallons handled daily	Total	Per 100 gallons handled daily
	Raw-milk storage		Pasteurizing and cooling		Total	Per 100 gallons handled daily	Size	Per 100 gallons handled daily						
	Size	Per 100 gallons handled daily	Size	Per 100 gallons handled daily										
	Sq. ft.	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*
1			500	62.5	500	62.5	300	37.5	800	100.0	400	50.0	2,450	306.2
2			550	36.7	550	36.7	375	25.0	925	61.7	550	36.7	2,175	145.0
3			1,300	43.3	1,300	43.3	1,200	40.0	2,500	83.3	1,200	40.0	6,400	213.3
4			744	19.6	744	19.6	320	8.4	1,064	28.0	690	18.2	3,942	103.7
5			540	13.5	540	13.5	700	17.5	1,240	31.0	1,426	35.7	5,556	138.9
6			720	12.0	720	12.0	720	12.0	1,440	24.0	1,110	18.5	6,380	106.3
7	979	13.1	885	11.8	1,864	24.9	318	4.2	2,182	29.1	1,760	23.5	6,124	81.6
8					1,600	17.8	1,000	11.1	2,600	28.9	1,680	18.7	7,190	79.9
9	650	6.6	1,500	15.3	2,150	21.9	840	8.6	2,990	30.5	1,250	12.8	12,865	131.3
10	810	4.1	2,790	14.0	3,600	18.0	1,587	7.9	5,187	25.9	3,848	19.2	21,341	106.7
11	2,200	6.3	1,840	5.3	4,040	11.5	800	2.3	4,840	13.8	4,000	11.4	20,440	58.4

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[1] No separate receiving room at this plant.

FLOOR PLANS FOR MILK PLANTS [9]

Floor plans designed by the Bureau of Dairy Industry for plants of various sizes are presented in Figures 16 to 21, inclusive. While a prospective builder would probably not desire to arrange his plant exactly in accordance with any of these floor plans, the various layouts and arrangements should be of assistance in designing a plan for a particular set of conditions, and these plans are presented for the purpose of suggesting possible arrangements. The arrangement and layout selected will depend largely on the building site available and the equipment selected.

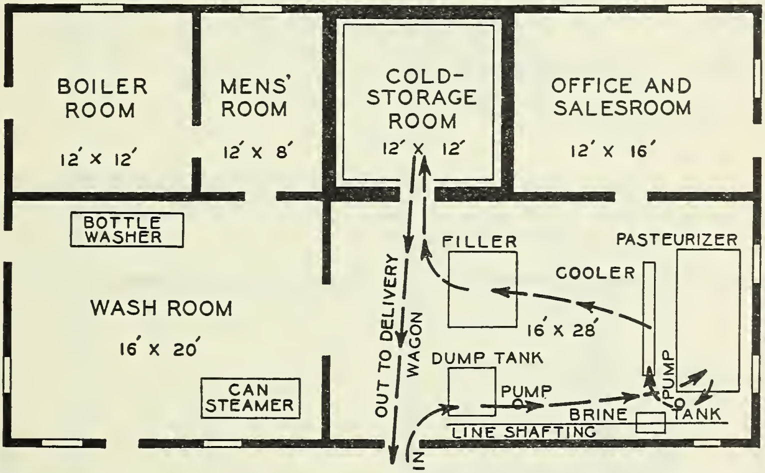

FIGURE 16.—Floor plan for a 1-story plant of about 500 gallons daily capacity, showing course of milk through plant

SANITARY REQUIREMENTS

WATER SUPPLY

An abundant supply of water should be available at the plant at all times. Large quantities of water are required for pasteurizing and cooling, for boilers and refrigerating machinery, and also for washing purposes. The quantity required for washing bottles and cans and cleaning up milk apparatus is considerable, and, besides, there are the requirements necessary for keeping the floors and walls well washed. Table 11 shows the quantity of water used at several plants of various sizes.

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[9] K. E. Parks, dairy engineer of the Bureau of Dairy Industry, gave valuable suggestions and assistance in regard to the designing of the floor plans shown in this circular. The Bureau of Agricultural Engineering also cooperated in preparing the plans for figs. 20 and 21.

TABLE 11.—*Quantity of water used at milk plants of various sizes*

Capacity of plant (gallons)	Average quantity of milk handled daily	Quantity of water used daily		Quantity of water used daily per 100 gallons milk handled	
		Average	Range	Average	Range
	Gallons	*Gallons*	*Gallons*	*Gallons*	*Gallons*
Up to 1,000	500	4, 800	(1)	960	(1).
1,001 to 2,000	1,566	14, 255	11,000 to 18,300	909	520 to 1,220.
2,001 to 3,000	2, 692	11, 722	6,710 to 17,235	436	287 to 580.
3,001 to 5,000	3, 500	17, 735	3,070 to 32,400	509	77 to 1,080.
5,001 to 10,000	6, 788	16, 135	(1)	238	(1).
Over 10,000	15, 999	112, 007	102,000 to 122.015	700	611 to 850.

[1] Only one plant in group.

STEAM

It is important that all milk-handling equipment be steamed immediately after it is washed, and plenty of live steam must be available. A convenient arrangement is to have a pipe and valve connected with the city water supply and another pipe and valve connected with the steam system, the two pipes being joined by a T head to a common outlet or nozzle. By the use of such a connection cold water is made available by opening the water valve, steam by opening the steam valve, and hot water by turning on both the water and steam valves.

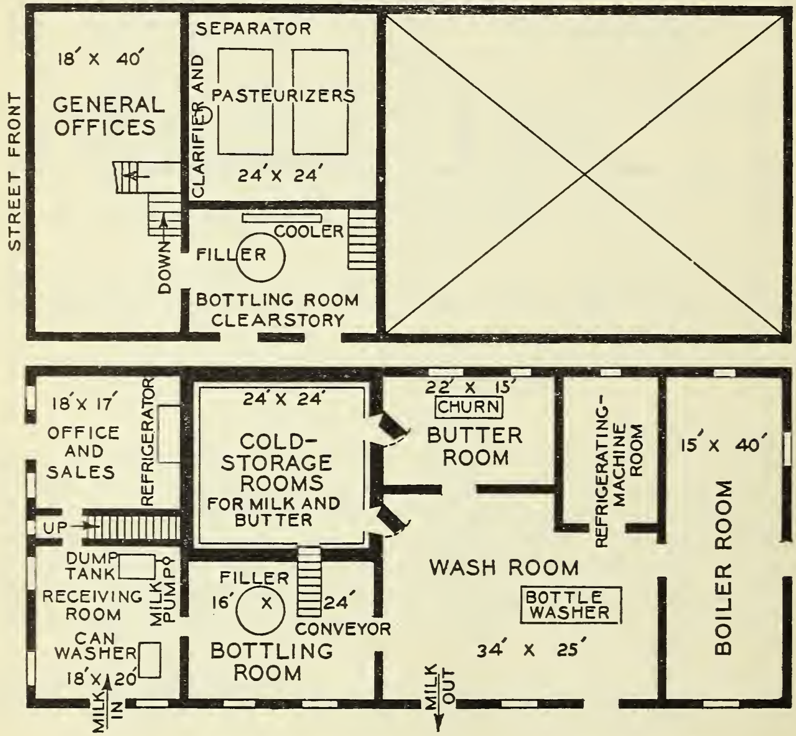
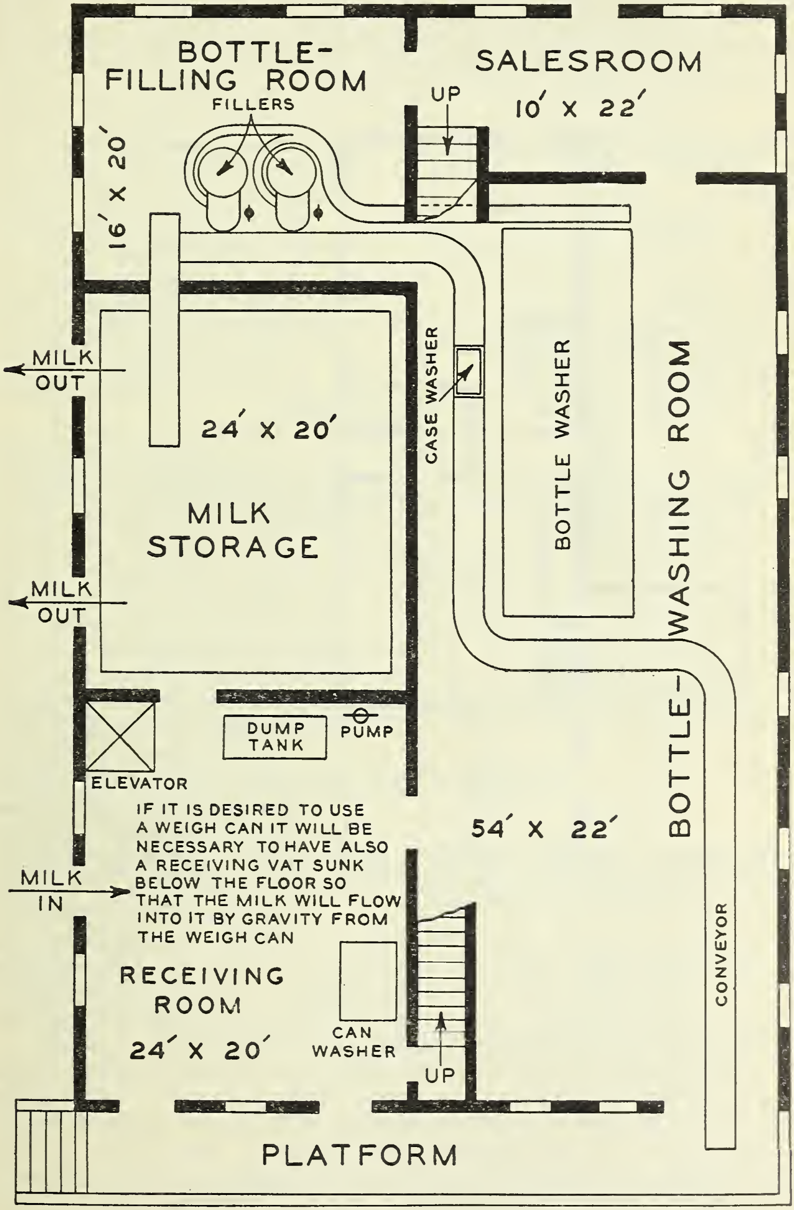


FIGURE 17.—Floor plans for a 1½-story plant of from 1,500 to 2,000 gallons daily capacity

VENTILATION

Good ventilation is essential in a milk plant, in order to get rid of bad air and moisture and to insure an ample supply of pure air.



IF IT IS DESIRED TO USE A WEIGH CAN IT WILL BE NECESSARY TO HAVE ALSO A RECEIVING VAT SUNK BELOW THE FLOOR SO THAT THE MILK WILL FLOW INTO IT BY GRAVITY FROM THE WEIGH CAN

FIGURE 18.—First-floor plan for a 2-story plant of from 2,000 to 3,000 gallons daily capacity

In many of the plants studied, especially the smaller ones, the ventilation was inadequate, no provision being made to ventilate the plant except by windows and doors. It is difficult to get good ventilation by this method.

Plants of medium to large size should not rely on natural ventilating systems, but should be equipped with fans or ventilators. Many modern milk plants have an artificial system of ventilation by which the intake air, as pure as can be obtained, is drawn or forced by a fan through a filter or a spray of water, and then is forced through flues into the rooms. The openings from these flues or ducts into the rooms may be near the ceiling or near the floor, but usually they are about midway between. By heating or cooling the spray of water, the temperature of the air in the rooms may be controlled to a certain extent. Other flues leading to the outside of the building are provided to take the bad air out.

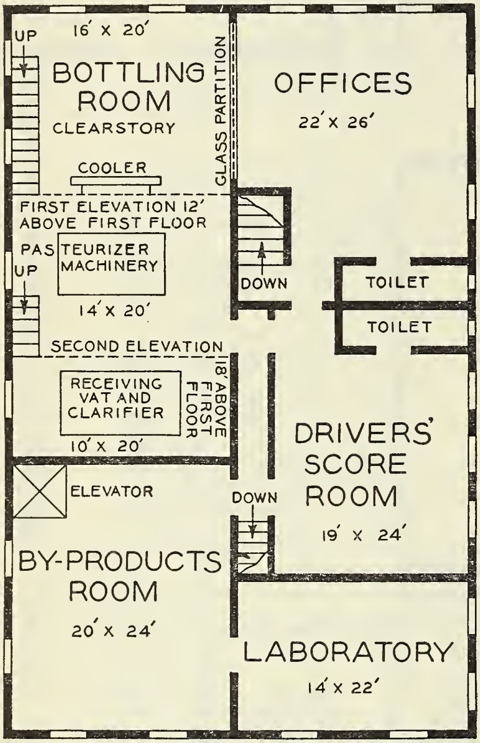


FIGURE 19.—Second-floor plan for a 2-story plant of from 2,000 to 3,000 gallons daily capacity

In large plants the process most commonly used for filtering air consists in forcing air through one or more thicknesses of cheesecloth, or cloth and absorbent cotton. The air is forced into the room through the filter under a low pressure, so that the used air has a tendency to pass outward through the openings near the ceiling provided for outgoing air. All air coming into the room must pass through the filter. At some plants, before air is forced into the rooms, it is cooled in summer by passing over brine coils and warmed in winter by passing over steam coils.

For medium-sized plants, an exhaust fan, with a set of flues leading from the different rooms, should be provided. It may also be necessary, in some instances, to install an air filter to prevent dust entering the plant and getting into the milk.

For small plants, if no fan is provided, there should be some system of natural ventilation other than doors and windows. A flue system similar to that used in dairy barns is an efficient ventilator for small buildings and is not expensive. By installing outlet flues through which the impure air can pass out, and allowing air to come in through the windows, fairly good ventilation can be obtained.

Good ventilation in the milk-storage room is important but is often neglected. In many plants the milk-storage room is very poorly ventilated. On account of loss of refrigeration it is of course impracticable to have open windows in this room; consequently, an artificial system of ventilation should be provided. Otherwise, ventilation will be sluggish and the best results will not be obtained from the cooling coils. Also, moisture will condense on the ceiling and cause constant dripping, which is very uncomfortable and insanitary. In plants where artificial ventilation is impracticable, considerable improvement can sometimes be made by using an ordinary electric fan, which will keep the air in circulation and produce better results from the cooling coils.

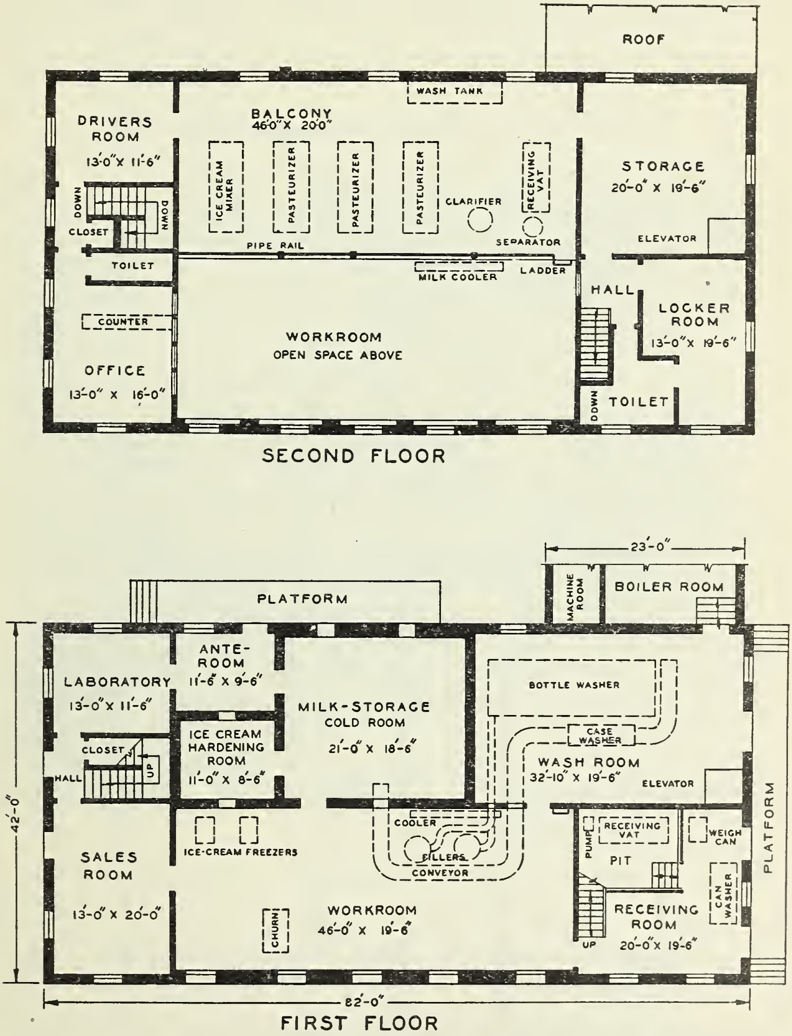


FIGURE 20.—Floor plans for a 2-story plant to handle about 3,000 gallons of milk and 300 gallons of ice cream daily

A considerable number of modern plants have an indirect method of cooling the milk-storage room which also serves as a ventilating system. The intake air is blown over ice bunkers or refrigerating coils in another room, and is then forced through flues into the milk-storage room. (Fig. 22.) The cold air on entering this room flows downward, and the warmer air rises and passes out through other openings and is again drawn over the refrigerating coils, so that a constant circulation of clean, dry, cold air is maintained.

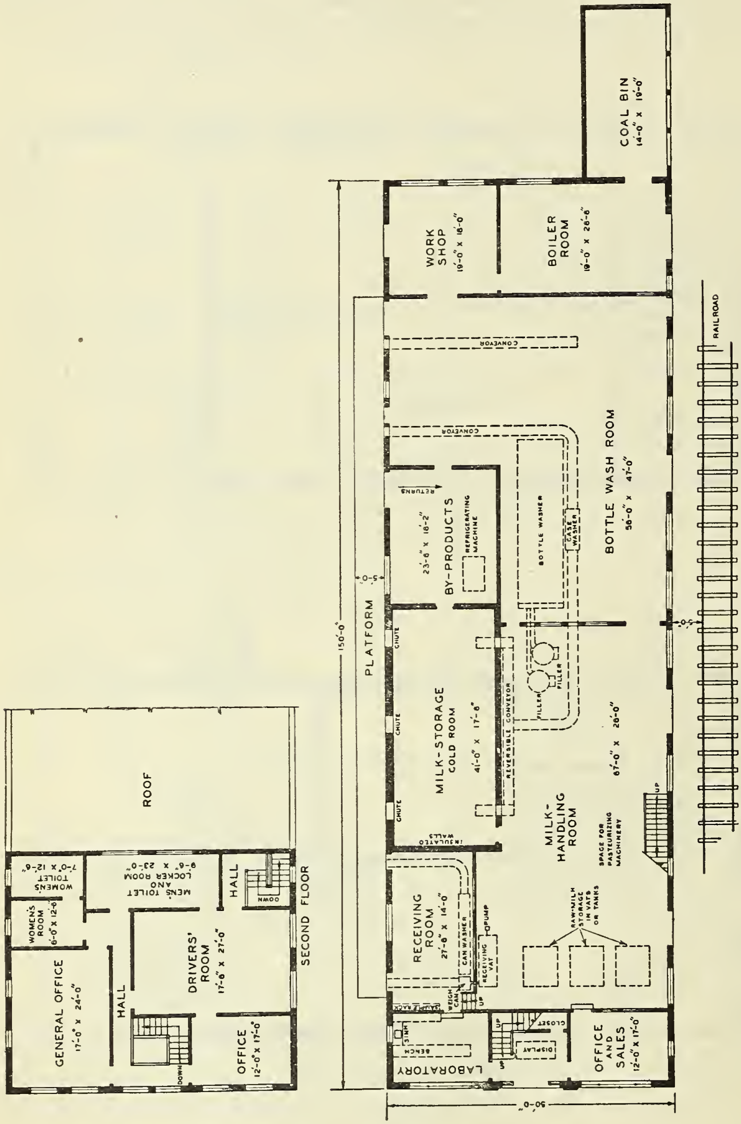

COAL BIN 14'-0" x 19'-0"
WORK SHOP 19'-0" x 16'-0"
BOILER ROOM 19'-0" x 26'-6"
CONVEYOR
CONVEYOR
RAILROAD
BOTTLE WASH ROOM 56'-0" x 47'-0"
BOTTLE WASHER
CASE WASHER
RETURNS
BY-PRODUCTS 23'-6" x 16'-2"
REFRIGERATING MACHINE
150'-0"
5'-0"
PLATFORM
CHUTE
CHUTE
CHUTE
MILK-STORAGE COLD ROOM 41'-0" x 17'-6"
REVERSIBLE CONVEYOR
FILLER
FILLER
5'-0"
MILK-HANDLING ROOM 67'-0" x 26'-0"
SPACE FOR PASTEURIZING MACHINERY
INSULATED WALLS
UP
RAW-MILK STORAGE IN VATS OR TANKS
RECEIVING ROOM 27'-6" x 14'-0"
CAN WASHER
PUMP
RECEIVING VAT
WEIGH CAN
UP
SINK
BENCH
LABORATORY
UP
CLOSET
DISPLAY
OFFICE AND SALES 12'-0" x 17'-6"
50'-0"
ROOF
WOMEN'S TOILET 7'-0" x 12'-6"
MEN'S TOILET AND LOCKER ROOM 9'-6" x 23'-0"
HALL
DOWN
WOMEN'S ROOM 6'-0" x 12'-6"
DRIVERS' ROOM 17'-6" x 27'-0"
GENERAL OFFICE 17'-0" x 24'-0"
HALL
DOWN
OFFICE 12'-0" x 17'-0"
SECOND FLOOR

FIGURE 21.—Floor plan for a 1-story plant of about 5,000 gallons daily capacity

MISCELLANEOUS REQUIREMENTS

Screens should be attached to all windows and doors during the fly season. The screens should be on the outside of the casing and should open outward. The receiving room, especially, should be well closed in and screened, and self-closing devices should be attached to the doors opening into this room, as well as to other doors through which workmen pass continually. Electric fans will also aid in keeping flies away from the milk and equipment. Double doors at the entrance of the plant with fans blowing toward them will aid in keeping the flies out.

It is important to have a special room for drivers and other employees. In this room a locker for each man's working clothes is essential, and shower baths and toilet facilities should be provided in an adjoining room.

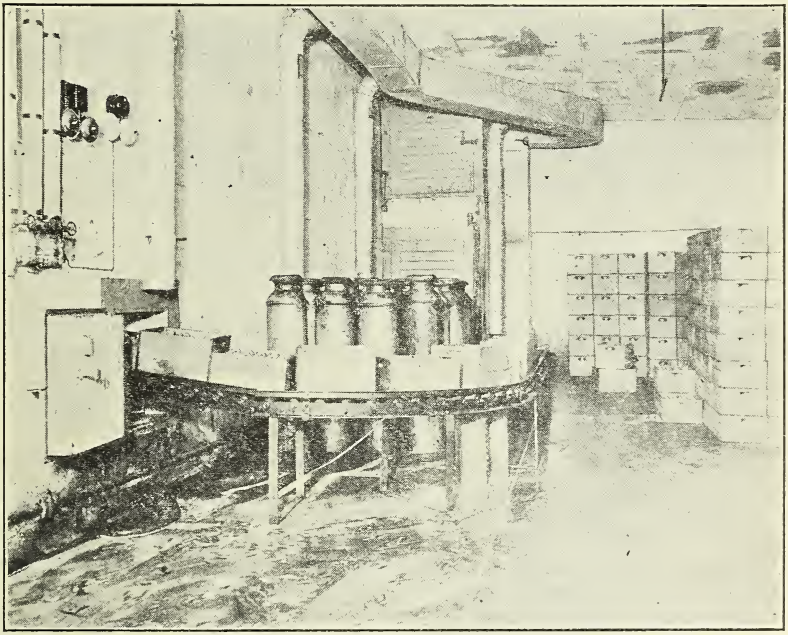


FIGURE 22.—Milk-storage room with indirect system of cooling. Note flues through which cold air is fanned into the room

The milk plant frequently can operate a laundry to advantage, especially if the men's white working suits are washed by the plant. If their working clothes are cleaned at the milk plant's expense, the men will be more likely to change them often.

Aside from the general toilet facilities in the wash room, it is advisable to have a washbowl, with soap and towels handy, in the milk-handling room. Employees in the handling room often get their hands dirty from setting up machinery, handling bottles, cases, etc., and it is desirable to have a convenient place for them to wash their hands before handling clean bottles or engaging in other operations involving milk.

Milk apparatus should be covered so as to expose the milk to the air as little as possible. This caution refers especially to vats, coolers, and bottling machines.

SUMMARY

Conditions should be thoroughly investigated and found to be favorable before the establishment of a milk plant is attempted.

For large plants the assistance of a competent architect in making plans is required. Plans for a small plant can often be drawn without such aid.

Favorable location of the plant is important. Among the factors to be considered are: Convenience of getting the raw supply to the plant, proximity to distribution area, advertising possibilities, and ample space to afford an efficient arrangement of the plant.

Plants may be classified in seven classes, according to the way the milk is handled. In many modern plants all the operations of milk handling are on the first floor. Comparatively few plants now use the gravity system of handling the milk.

Plants may also be classified on the basis of the course of the bottles through the plant. The most common and also the most desirable system is to have all the bottle washing and filling operations on the first floor.

The plant should be so arranged that provision may be made for enlarging it when necessary, without interfering with the convenient arrangement of the rooms and apparatus.

The number of stories in plants varies from one to four or more, but the majority of modern plants are usually of only one or two stories.

The labor requirements for operating plants of three of more stories are greater than those for plants of one or two stories.

The transferring of bottles from one floor to another tends to cause excessive breakage of bottles.

Up-to-date plants are usually constructed of brick, concrete, or hollow tile, finished on the inside with smooth cement.

Inside walls should have a smooth finish. Tile or enamel brick are desirable for the bottling and pasteurizing rooms.

Concrete or tile floors are desirable in all milk plants. Tile floors in the bottling rooms add to the appearance.

Floors must be well drained and have proper connection with the sewer.

In the arrangement of the plant economy of operation as well as sanitation should be considered. It is desirable that the plant be so arranged that there will be a minimum of milk pumps and piping.

The receiving room should be so arranged that the cans of milk will be transferred to the weigh can, and the empty cans from the can washer automatically, with a minimum of handling.

It is more economical of labor to pump the raw milk than to elevate it in cans on elevators or conveyors.

The bottles should be checked in on conveyors so arranged that there will be a minimum of stacking of bottles between the checking-in platform and the bottle washers. At small plants no transfer system is necessary if the bottle washer is placed near the checking-in platform.

Where a large number of routes are to be checked out, the system of loading out directly from the milk-storage room through several small doors or from several trailers is desirable. At small plants either one door direct from the milk-storage room or trucks are satisfactory.

In a well-arranged plant with power-controlled conveyors there will be less bottle breakage than in a poorly arranged plant.

For convenience, economy, and sanitation the plant should be divided into the following separate rooms: Receiving room, pasteurizing or handling room, bottling room, wash room, by-products room, milk-storage room, salesroom, offices, and laboratory. The boiler room should be separate from the rest of the plant.

Each room should be of ample size to accommodate the equipment it contains, with sufficient space for the men to work and to clean the equipment, but there should be no waste space.

There is a great variation in the number of men required to operate plants of similar capacities due, in a large measure, to the arrangement of the plants. Poorly arranged plants tend to increase the labor requirements.

The plant should be sanitary in every way; plenty of water and steam should always be available; good ventilation and light are essential.

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